Avaliação Pontual 3 - Arquivo Rat

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Dados Correlacionados - 11/04/2021

Avaliação Pontual 3

Especificação das estruturas de média e covariância do modelo linear geral para dados longitudinais com resposta contínua.

Na resolução especifique qual o conjunto (Capítulo) de exercícios você escolheu; apresente os códigos utilizados, as saídas e suas conclusões.

Capítulo 6 (páginas 163 e 164) - arquivo rat.dta.

Conjunto de Dados Rat - Capítulo 6

In a study of weight gain (Box, 1950) investigators randomly assigned 30 rats to three treatment groups:

treatment 1 was a control (no additive); treatments 2 and 3 consisted of two different additives (thiouracil and thyroxin respectively) to the rats drinking water.

Weight, in grams, was measured at baseline (week 0) and at weeks 1, 2, 3, and 4.

Due to an accident at the beginning of the study, data on 3 rats from the thyroxin group are unavailable.

The variable Group is coded 1 = control, 2 = thiouracil, and 3 = thyroxin.

```
## # A tibble: 6 x 7
##      id group    y1    y2    y3    y4    y5
##   <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
## 1     1     1    57    86   114   139   172
## 2     2     1    60    93   123   146   177
## 3     3     1    52    77   111   144   185
## 4     4     1    49    67   100   129   164
## 5     5     1    56    81   104   121   151
## 6     6     1    46    70   102   131   153
```

Remodelando e Transformando os Dados

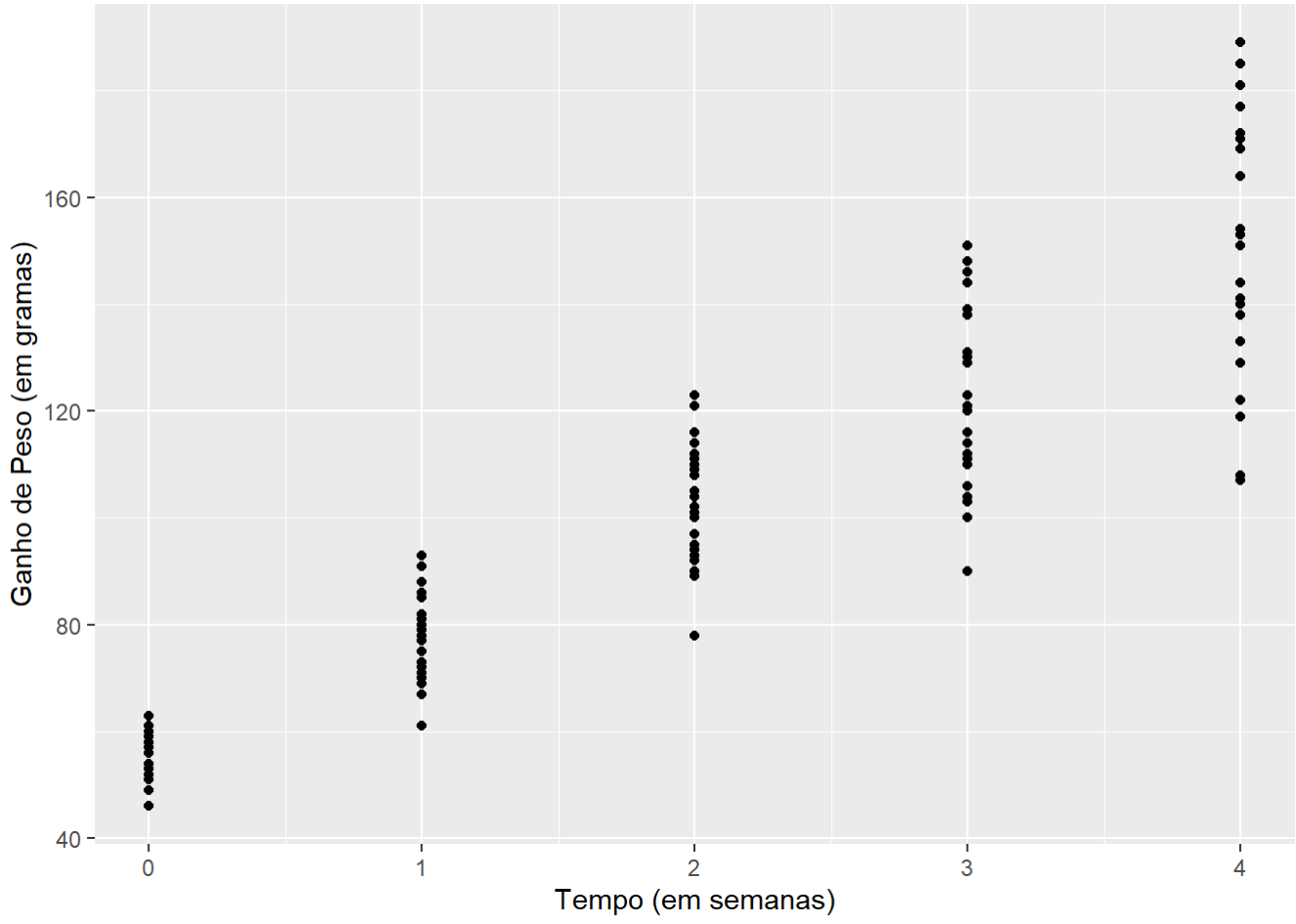
Para melhor trabalhar e analisar os dados longitudinais, utilizamos o formato ‘longo’ ao invés do formato ‘largo’ da seguinte forma: as medidas repetidas são empilhadas em uma única coluna; a coluna id, e demais covariáveis fixas no tempo, repetem o seu valor; e uma nova coluna que indexa as ocasiões, ou com os valores dos tempos de medição, é criada.

```
## # A tibble: 10 x 5
##       id group   tempo  peso tempo.f
##    <dbl> <fct>   <dbl> <dbl> <fct>
##  1     1 control     0    57 0
##  2     2 control     0    60 0
##  3     3 control     0    52 0
##  4     4 control     0    49 0
##  5     5 control     0    56 0
##  6     6 control     0    46 0
##  7     7 control     0    51 0
##  8     8 control     0    63 0
##  9     9 control     0    49 0
## 10    10 control     0    57 0
```

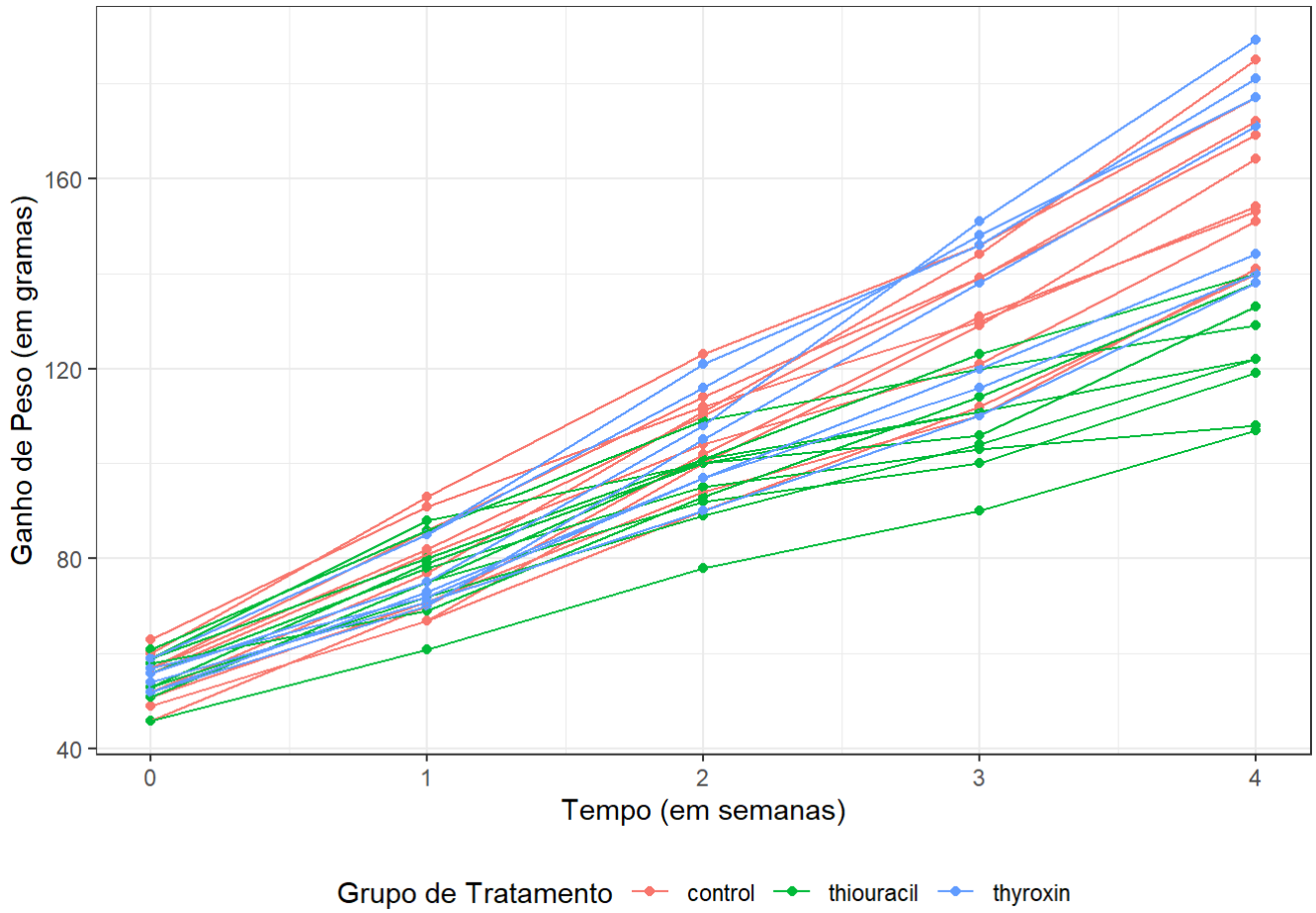
Time Plot

Utilizaremos o time plot para observar as trajetórias individuais, tendências, variabilidade entre e dentro de indivíduos (leia-se ratinhos).

Primeiro pelo Diagrama de Dispersão. Onde notamos um ganho de peso conforme o tempo vai passando.

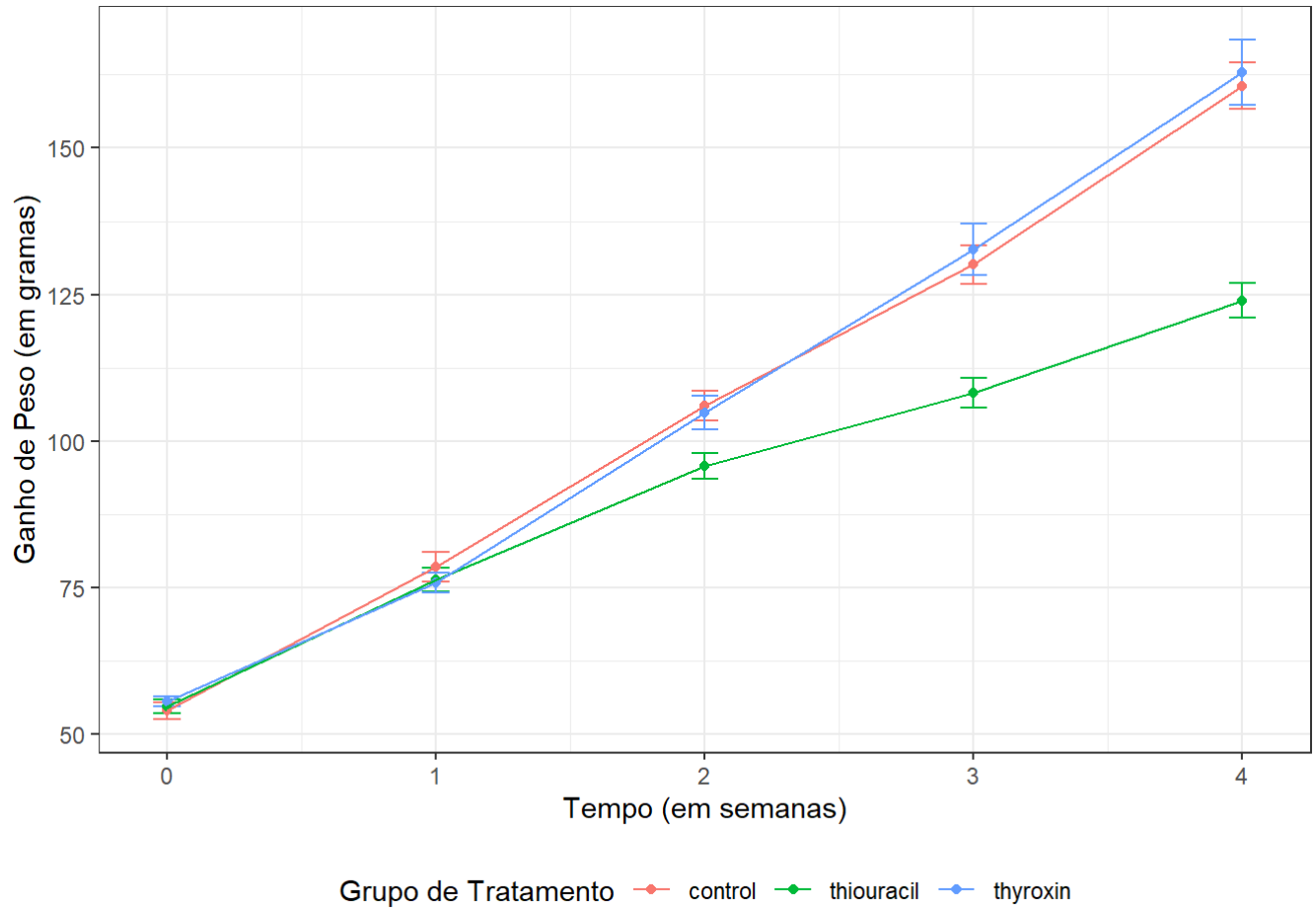


E também pelos Perfis Individuais (Spaghetti).

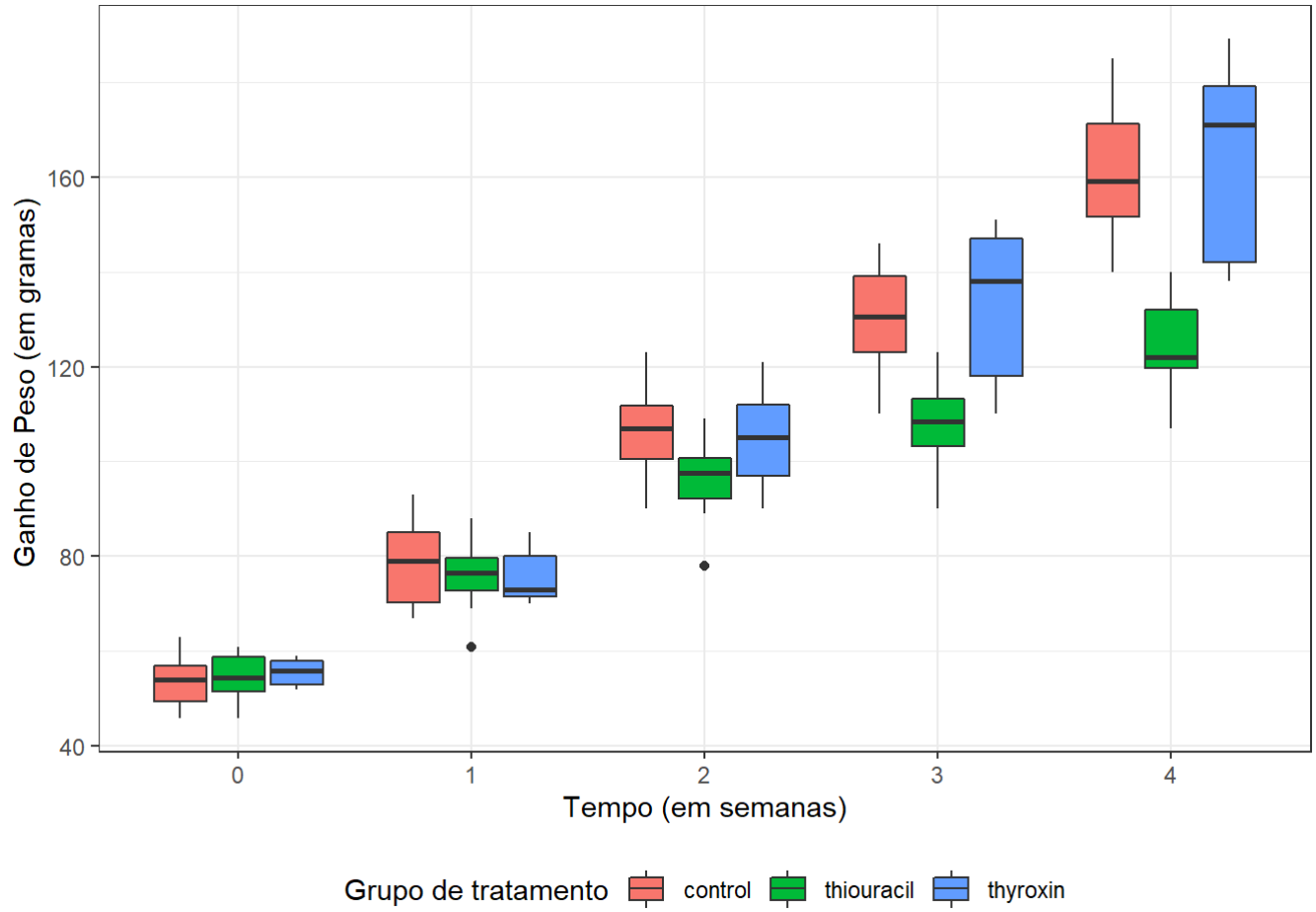


Para uma análise mais informativa, utilizaremos também os Perfis de Médias (com barras de erros + boxplot).

```
##         group tempo peso.m        dp       ep
## 1     control     0   54.0  5.436502 1.403699
## 2     control     1   78.5  9.640770 2.489236
## 3     control     2  106.0  9.921917 2.561828
## 4     control     3  130.1 12.564942 3.244254
## 5     control     4  160.6 15.196491 3.923717
## 6  thiouracil     0   54.7  4.691600 1.211366
## 7  thiouracil     1   76.3  7.916930 2.044142
## 8  thiouracil     2   95.8  8.495751 2.193593
## 9  thiouracil     3  108.2  9.750214 2.517494
## 10 thiouracil     4  124.0 11.254629 2.905933
```



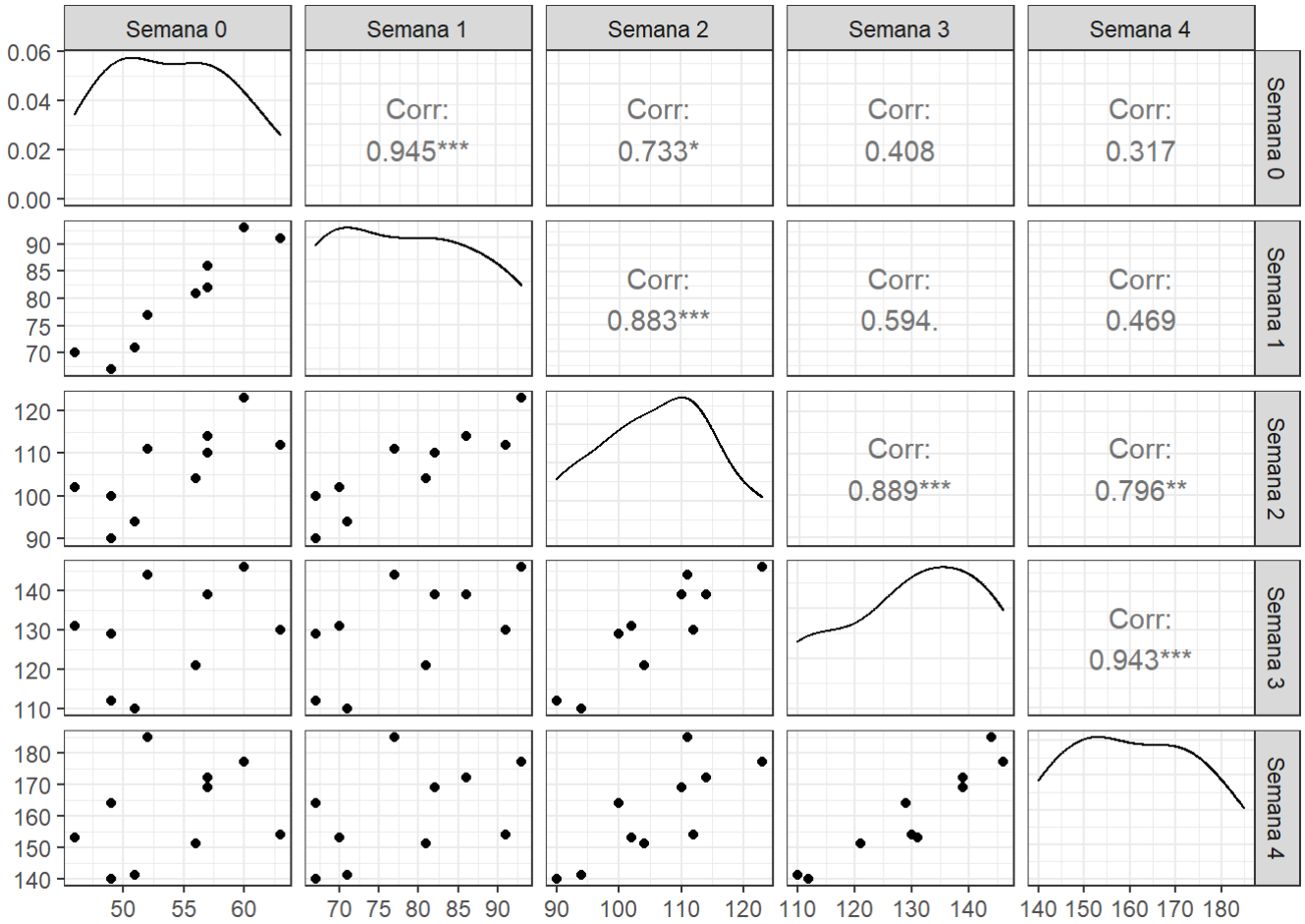
Os grupos de tratamento control e thyroxin apresentam um comportamento muito semelhante nos grupos conforme passa o tempo.



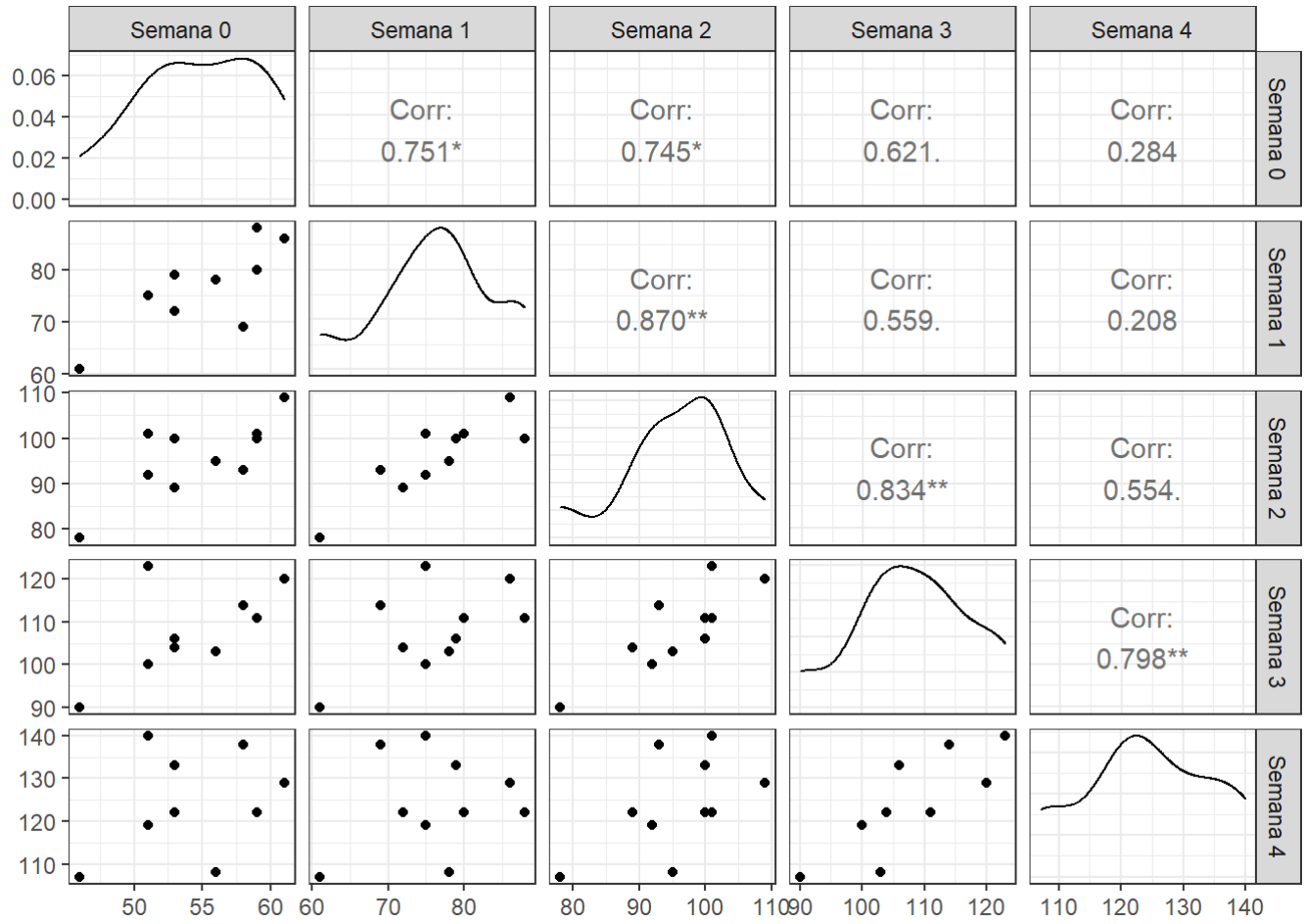
Estrutura de Correlação

Estrutura de correlação para os diferentes grupos de tratamento.

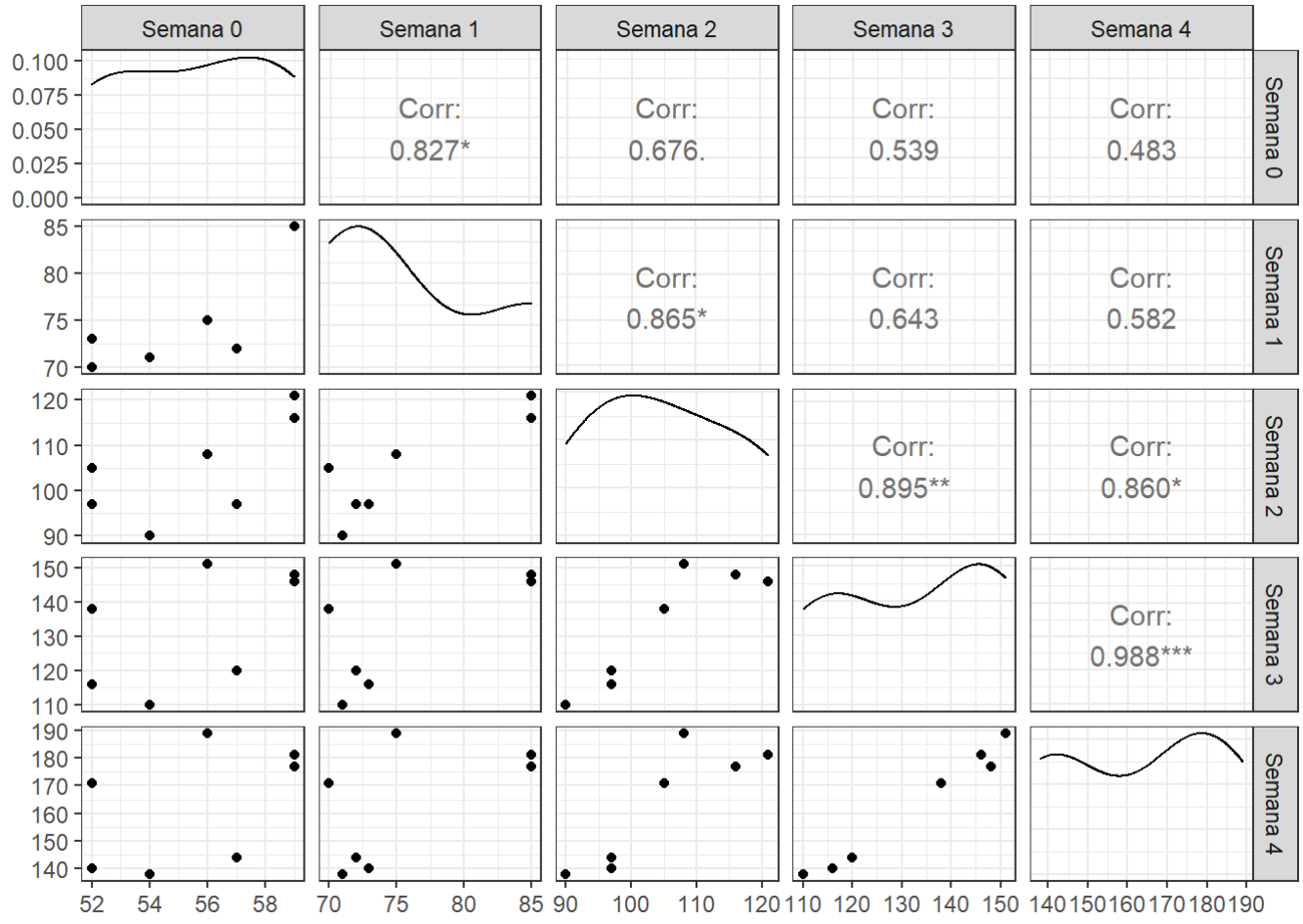
```
## control
```




```
## thiouracil
```


Semana 0
Semana 1
Semana 2
Semana 3
Semana 4
Corr:
0.751*
Corr:
0.745*
Corr:
0.621.
Corr:
0.284
Corr:
0.870**
Corr:
0.559.
Corr:
0.208
Corr:
0.834**
Corr:
0.554.
Corr:
0.798**

```
## thyroxin
```


Semana 0
Semana 1
Semana 2
Semana 3
Semana 4
Corr:
0.827*
Corr:
0.676.
Corr:
0.539
Corr:
0.483
Corr:
0.865*
Corr:
0.643
Corr:
0.582
Corr:
0.895**
Corr:
0.860*
Corr:
0.988***

Modelo de Perfis de Respostas

```
## Generalized least squares fit by REML
##   Model: peso ~ group * tempo
##   Data: ratos.longo
##        AIC      BIC    logLik
##   854.5993 914.6554 -406.2996
##
## Correlation Structure: General
##  Formula: ~1 | id
##  Parameter estimate(s):
##  Correlation:
##   1     2     3     4
## 2 0.869
## 3 0.714 0.852
## 4 0.456 0.518 0.813
## 5 0.228 0.255 0.634 0.904
## Variance function:
##  Structure: Different standard deviations per stratum
##  Formula: ~1 | tempo
##  Parameter estimates:
##        0        1        2        3        4
## 1.000000 1.908210 2.082301 2.638103 3.269681
##
## Coefficients:
##                           Value Std.Error  t-value p-value
## (Intercept)           55.35233  1.310735 42.22998  0.0000
## groupthiouracil       -1.91155  1.853660 -1.03123  0.3044
## groupthyroxin          3.00597  2.042634  1.47162  0.1436
## tempo                 26.17850  1.042360 25.11465  0.0000
## groupthiouracil:tempo -7.52867  1.474119 -5.10723  0.0000
## groupthyroxin:tempo   -1.41434  1.624400 -0.87068  0.3855
##
##  Correlation:
##                       (Intr) grpthr grpthy tempo  grpthr:
## groupthiouracil       -0.707
## groupthyroxin         -0.642  0.454
## tempo                  0.284 -0.201 -0.183
## groupthiouracil:tempo -0.201  0.284  0.129 -0.707
## groupthyroxin:tempo   -0.183  0.129  0.284 -0.642  0.454
##
## Standardized residuals:
##         Min          Q1         Med          Q3         Max
## -1.89467664 -0.92721925 -0.00962018  0.73647815  1.95700324
##
## Residual standard error: 4.93611
## Degrees of freedom: 135 total; 129 residual
```

Matriz de Covariância Estimada

24.4	44.1	56.9	21.2	14.7
44.1	105.6	141.4	50.1	34.1
56.9	141.4	260.5	123.7	133.3

21.2	50.1	123.7	88.7	110.8
14.7	34.1	133.3	110.8	169.6

Aumento perceptível na variância dos ganhos de peso dos ratos.

Teste de Wald

	Df	Chisq	Pr(>Chisq)
group	2	3.39	0.1834
tempo	1	1317.25	0.0000
group:tempo	2	28.72	0.0000

Rejeitamos a hipótese de ausência de efeito de interação grupo x tempo.

Teste da Razão de Verossimilhança

```
##                 Model df      AIC      BIC    logLik   Test L.Ratio p-value
## modelo.completo     1 21 867.5989 928.6097 -412.7995
## modelo.reduzido     2 19 878.2347 933.4349 -420.1174 1 vs 2 14.6358   7e-04
```

Como p-valor < 0.001, então rejeitamos a hipótese de ausência de efeito de interação, portanto o modelo completo é mais adequado para descrever os dados.

Coeficientes Estimados

	Estimativa	EP	Z
(Intercept)	55.352	1.311	42.23
groupthiouracil	-1.912	1.854	-1.03
groupthyroxin	3.006	2.043	1.47
tempo	26.178	1.042	25.11
groupthiouracil:tempo	-7.529	1.474	-5.11
groupthyroxin:tempo	-1.414	1.624	-0.87

Modelo Spline Linear

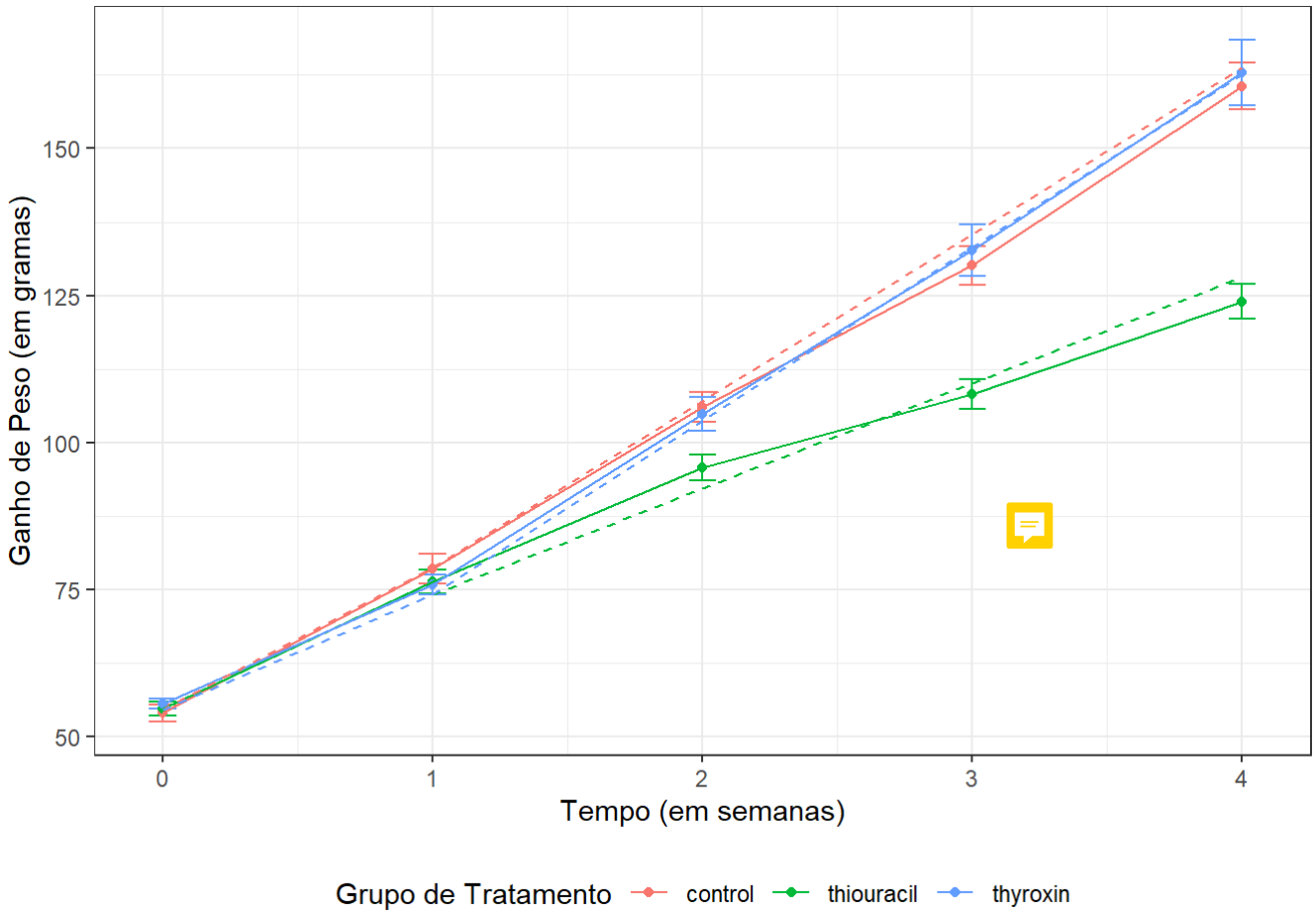
```
## Generalized least squares fit by REML
##   Model: peso ~ lspline(x = semana, knots = 1, marginal = TRUE) + lspline(x = semana,
knots = 1, marginal = TRUE):group
##   Data: ratos.longo
##        AIC      BIC   logLik
##   839.5219 902.2666 -397.761
##
## Correlation Structure: General
##  Formula: ~tempo | id
##  Parameter estimate(s):
##  Correlation:
##   1     2     3     4
## 2 0.842
## 3 0.676 0.853
## 4 0.450 0.522 0.815
## 5 0.305 0.364 0.699 0.931
## Variance function:
##  Structure: Different standard deviations per stratum
##  Formula: ~1 | tempo
##  Parameter estimates:
##        1        2        3        4        5
## 1.000000 1.816880 2.172740 2.923265 3.558180
##
## Coefficients:
##                                                                    Value
## (Intercept)                                                     54.56803
## lspline(x = semana, knots = 1, marginal = TRUE)1                24.17461
## lspline(x = semana, knots = 1, marginal = TRUE)2                 4.18747
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthiouracil -4.55435
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthiouracil -5.82764
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthyroxin   -4.58261
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthyroxin    5.70444
##                                                                 Std.Error
## (Intercept)                                                     0.8599471
## lspline(x = semana, knots = 1, marginal = TRUE)1                1.3624983
## lspline(x = semana, knots = 1, marginal = TRUE)2                1.9581475
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthiouracil 1.8297904
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthiouracil 2.6646935
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthyroxin   2.0163308
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthyroxin   2.9363492
##                                                                  t-value
## (Intercept)                                                     63.45510
## lspline(x = semana, knots = 1, marginal = TRUE)1                17.74286
## lspline(x = semana, knots = 1, marginal = TRUE)2                 2.13848
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthiouracil -2.48900
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthiouracil -2.18698
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthyroxin   -2.27275
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthyroxin    1.94270
##                                                                 p-value
## (Intercept)                                                      0.0000
## lspline(x = semana, knots = 1, marginal = TRUE)1                 0.0000
## lspline(x = semana, knots = 1, marginal = TRUE)2                 0.0344
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthiouracil  0.0141
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthiouracil  0.0306
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthyroxin    0.0247
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthyroxin    0.0542
##
```

```
##  Correlation:
##                                                                    (Intr)
## lspline(x = semana, knots = 1, marginal = TRUE)1                    0.313
## lspline(x = semana, knots = 1, marginal = TRUE)2                   -0.272
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthiouracil    0.000
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthiouracil    0.000
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthyroxin      0.000
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthyroxin      0.000
##                                                                    ls(=s,k=1,m=TRUE)1
## lspline(x = semana, knots = 1, marginal = TRUE)1
## lspline(x = semana, knots = 1, marginal = TRUE)2                   -0.666
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthiouracil -0.671
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthiouracil  0.427
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthyroxin   -0.609
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthyroxin    0.387
##                                                                    ls(=s,k=1,m=TRUE)2
## lspline(x = semana, knots = 1, marginal = TRUE)1
## lspline(x = semana, knots = 1, marginal = TRUE)2
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthiouracil  0.432
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthiouracil -0.680
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthyroxin    0.392
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthyroxin   -0.617
##                                                                    lspln(x=smn,knts=1,mrgnl=
TRUE)1:grpthr
## lspline(x = semana, knots = 1, marginal = TRUE)1
## lspline(x = semana, knots = 1, marginal = TRUE)2
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthiouracil
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthiouracil -0.635
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthyroxin    0.454
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthyroxin   -0.288
##                                                                    lspln(x=smn,knts=1,mrgnl=
TRUE)2:grpthr
## lspline(x = semana, knots = 1, marginal = TRUE)1
## lspline(x = semana, knots = 1, marginal = TRUE)2
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthiouracil
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthiouracil
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthyroxin   -0.288
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthyroxin    0.454
##                                                                    lspln(x=smn,knts=1,mrgnl=
TRUE)1:grpthy
## lspline(x = semana, knots = 1, marginal = TRUE)1
## lspline(x = semana, knots = 1, marginal = TRUE)2
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthiouracil
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthiouracil
## lspline(x = semana, knots = 1, marginal = TRUE)1:groupthyroxin
## lspline(x = semana, knots = 1, marginal = TRUE)2:groupthyroxin   -0.635
##
## Standardized residuals:
##         Min          Q1         Med          Q3         Max
## -1.93333641 -0.67860948  0.06464495  0.74415319  1.87124439
##
## Residual standard error: 4.506078
## Degrees of freedom: 135 total; 128 residual
```

	Estimativa	EP	Z

	Estimativa	EP	Z
(Intercept)	54.5680	0.8599	63.46
lspline(x = semana, knots = 1, marginal = TRUE)1	24.1746	1.3625	17.74
lspline(x = semana, knots = 1, marginal = TRUE)2	4.1875	1.9581	2.14
lspline(x = semana, knots = 1, marginal = TRUE)1:groupthiouracil	-4.5544	1.8298	-2.49
lspline(x = semana, knots = 1, marginal = TRUE)2:groupthiouracil	-5.8276	2.6647	-2.19
lspline(x = semana, knots = 1, marginal = TRUE)1:groupthyroxin	-4.5826	2.0163	-2.27
lspline(x = semana, knots = 1, marginal = TRUE)2:groupthyroxin	5.7044	2.9363	1.94

```
## # Predicted values of id
## # x = semana
##
## # group = control
##
## x | Predicted
## -------------
## 0 |     54.57
## 1 |     78.74
## 2 |    107.10
## 3 |    135.47
## 4 |    163.83
##
## # group = thiouracil
##
## x | Predicted
## -------------
## 0 |     54.57
## 1 |     74.19
## 2 |     92.17
## 3 |    110.15
## 4 |    128.13
##
## # group = thyroxin
##
## x | Predicted
## -------------
## 0 |     54.57
## 1 |     74.16
## 2 |    103.64
## 3 |    133.13
## 4 |    162.61
##
## Adjusted for:
## * tempo =  3.00
## *    id = 14.00
```


Ganho de Peso (em gramas)
150
125
100
75
50
0
1
2
3
4
Tempo (em semanas)
Grupo de Tratamento
control
thiouracil
thyroxin