

Single group analysis with repeated measurements

February 27, 2024

Load packages

```
library(LMMstar)
library(lme4)
library(lmerTest)
library(ggplot2)
```

Load data and add 'artificial' sex variable and remove some variables:

```
data(gastricbypassW)
gastricbypassW$weight2 <- NULL
gastricbypassW$weight3 <- NULL
gastricbypassW$weight4 <- NULL
gastricbypassW$male <- as.numeric(gastricbypassW$id) %% 2
head(gastricbypassW)
```

	id	weight1	glucagonAUC1	glucagonAUC2	glucagonAUC3	glucagonAUC4	male
1	1	127.2	5032.50	4942.5	20421.0	9249.45	1
2	2	165.2	12142.50	14083.5	10945.5	7612.50	0
3	3	109.7	10321.35	6202.5	20121.0	17704.50	1
4	4	146.2	6693.00	6631.5	13090.5	4551.00	0
5	5	113.1	7090.50	NA	19155.0	12345.00	1
6	6	158.8	10386.00	7609.5	11778.0	8014.80	0

Reshape data to long format:

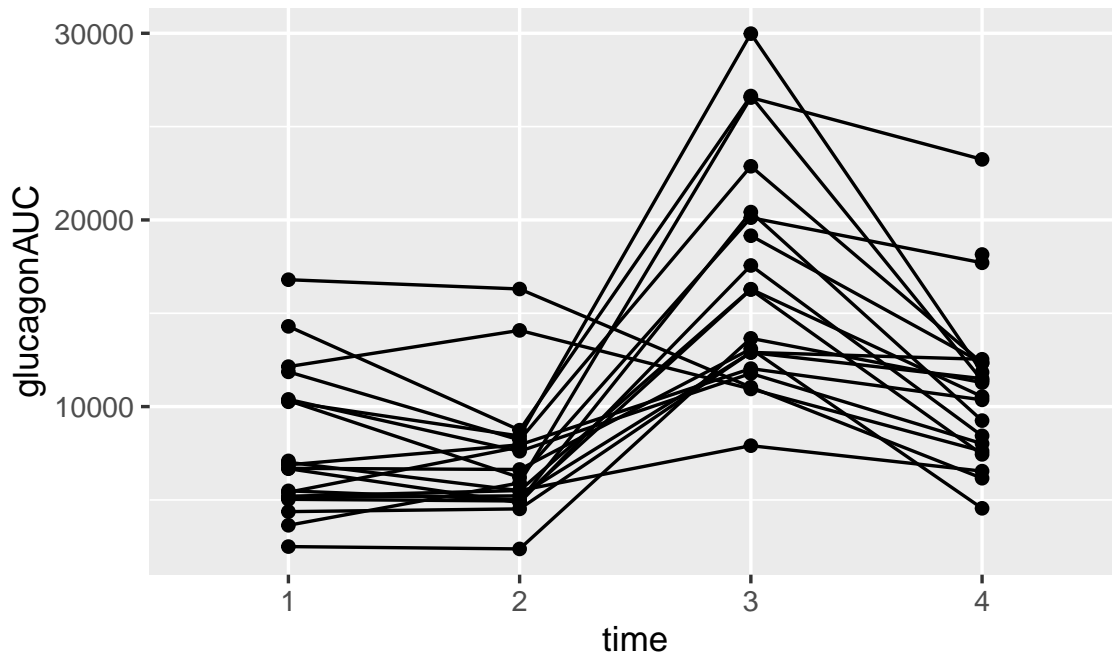
```
library(reshape2)
gastricbypassL <- melt(gastricbypassW,
                      id.vars = c("id", "male", "weight1"),
                      measure.var = paste0("glucagonAUC", 1:4),
                      variable.name = "time", value.name = "glucagonAUC")
gastricbypassL$time <- gsub("glucagonAUC", "", gastricbypassL$time)
gastricbypassL <- gastricbypassL[order(gastricbypassL$id),]
head(gastricbypassL)
```

	id	male	weight1	time	glucagonAUC
1	1	1	127.2	1	5032.50
21	1	1	127.2	2	4942.50
41	1	1	127.2	3	20421.00
61	1	1	127.2	4	9249.45
2	2	0	165.2	1	12142.50
22	2	0	165.2	2	14083.50

```

ggSpa <- ggplot(gastricbypassL, aes(x=time, y=glucagonAUC, group=id))
ggSpa <- ggSpa + geom_point() + geom_line()
ggSpa

```



1 My favorite approach

```
eUN.lmm <- lmm(glucagonAUC ~ time + male + weight1,
               repetition = ~time | id, structure = "CS",
               data = gastricbypassL)
anova(eUN.lmm)
```

Multivariate Wald test

	F-statistic	df	p.value
mean: time	14.752 (3,18.0)	4.3e-05	***
: male	0.055 (1,11.6)	0.819	
: weight1	1.308 (1, 7.7)	0.287	

```
eUN.lmmPairwiseTest <- anova(eUN.lmm,
                             effect = c("time2=0", "time4=0", "time4-time3=0"),
                             multivariate = FALSE)
summary(eUN.lmmPairwiseTest)
```

Univariate Wald test

	estimate	se	df	lower	upper	p.value
time2	-749.334	485.886	18.9	-2014.107	515.439	0.33716
time4	3202.583	1463.277	19	-606.366	7011.531	0.11308
time4 - time3	-6007.57	1157.98	16.9	-9021.821	-2993.319	0.00021 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Columns lower/upper/p.value adjusted for multiple comparisons -- max-test.

(1e+05 samples have been used)

Model-based standard errors are derived from the observed information (column se).

Degrees of freedom were computed using a Satterthwaite approximation (column df).

2 Other approach: repeated measurement anova

```
e.ranova <- aov(formula = glucagonAUC ~ male + weight1 + time + Error(id),
                 data = gastricbypassL)
summary(e.ranova)
```

Error: id

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
male	1	1894331	1894331	0.065	0.8029
weight1	1	115763362	115763362	3.943	0.0657 .
time	2	7936921	3968460	0.135	0.8746
Residuals	15	440438932	29362595		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Error: Within

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
time	3	1.145e+09	381688003	21.77	2.02e-09 ***
Residuals	55	9.645e+08	17537102		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

3 Other approach: random intercept model

```
e.lmer <- lmer(glucagonAUC ~ time + male + weight1 + (1 | id),
              data = gastricbypassL)
anova(e.lmer)
```

Type III Analysis of Variance Table with Satterthwaite's method

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
time	1148372460	382790820	3	56.107	21.9527	1.565e-09 ***
male	802158	802158	1	17.281	0.0460	0.83268
weight1	77654552	77654552	1	17.045	4.4534	0.04991 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Same as:

```
eCS.lmm <- lmm(glucagonAUC ~ time + male + weight1,
               repetition = ~time | id, structure = "CS",
               data = gastricbypassL)
anova(eCS.lmm)
```

Multivariate Wald test

	F-statistic	df	p.value
mean: time	21.95 (3,56.1)		1.57e-09 ***
: male	0.046 (1,17.3)		0.8327
: weight1	4.453 (1,17.1)		0.0499 *