MM2 HW7

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Read the grip data. It consists of 2 treatments (trt), 2 genders (gender), and 3 measurement occasions (time=1,2,3), a baseline covariate (x), and a response variable (y).

1.) Fit a marginal model for repeated measures including trt, gender, time, and x. Use the unstructured covariance for errors. Treat trt, gender, and time as categorical variables. State your model and assumptions.

SAS Code:

```
/* I think we can use both glimmix and mix */
proc glimmix data=grip;
    class trt gender time;
    model y=trt gender time x / solution ddfm=kr;
    random _residual_ / subject=subject type=un vcorr;
run;

proc mixed data=grip;
  class trt gender time;
  model y = trt gender time x / solution;
  repeated time / type=un subject=subject;
run;
```

I used both to compare outcomes, and they give relatively the same results. Our model:

$$y = 67.7588 + -1.2531 * trt_1 + -36.8416 * Female + -1.0910 * time_1 + 3.6568 * time_2 + 0.7431 * x$$

This marginal model assumts that y is continuous and normally distributed. It assumes that the residuals are IID. I believe we also need our repeated variable (time) to have $cov(time, trt) \sim cov(time, gender) \sim cov(time, x)$.

2.) Test whether there is an interaction between time and the other 3 predictor variables.

SAS CODE:

```
proc mixed data=grip;
    class trt gender time;
    model y=trt|time gender|time x|time / solution;
    repeated time / type=un subject=subject;
run;
```

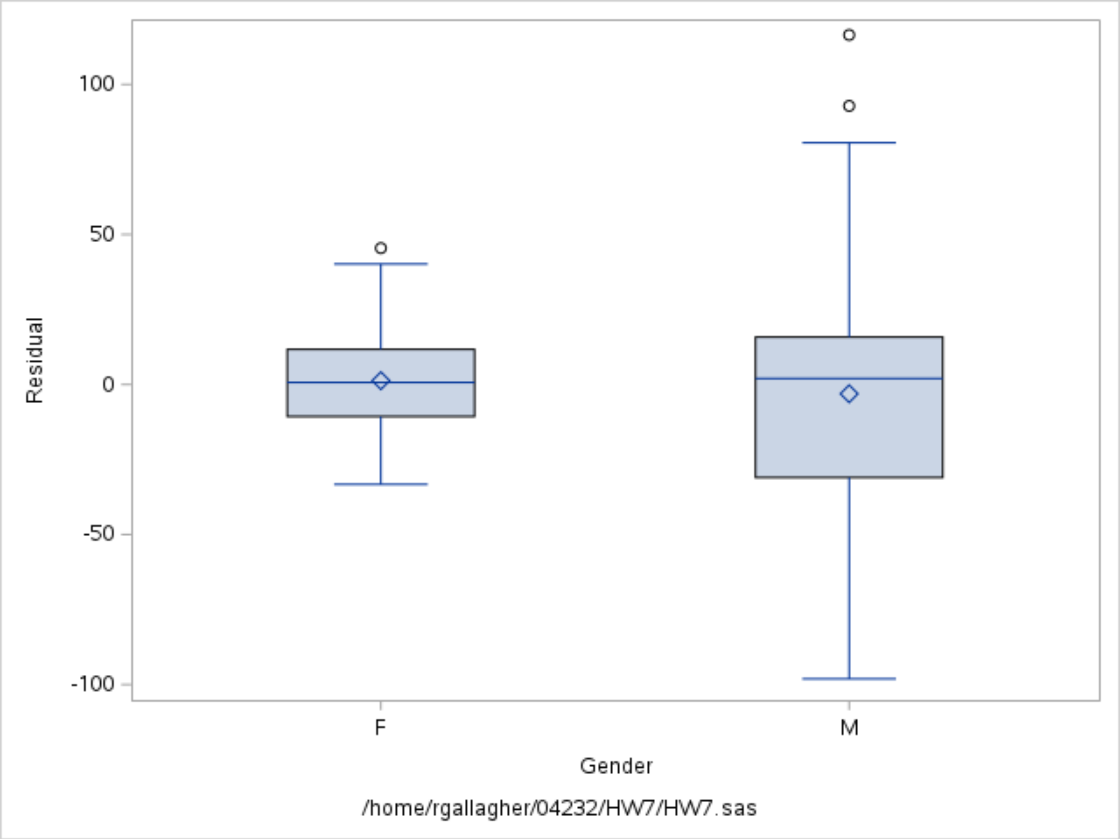
SAS OUTPUT:

Effect	Gender	trt	time	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept				64.1267	20.1602	63	3.18	0.0023
trt		1		2.0622	9.3901	63	0.22	0.8269
trt		2		0	.	.	.	.
time			1	-2.3002	20.3533	63	-0.11	0.9104
time			2	20.6555	12.5269	63	1.65	0.1041
time			3	0	.	.	.	.
trt*time		1	1	-2.4383	9.4753	63	-0.26	0.7978
trt*time		1	2	-6.2186	5.9195	63	-1.05	0.2975
trt*time		1	3	0	.	.	.	.
trt*time		2	1	0	.	.	.	.
trt*time		2	2	0	.	.	.	.
trt*time		2	3	0	.	.	.	.
Gender	F			-26.1487	14.1067	63	-1.85	0.0685
Gender	M			0	.	.	.	.
Gender*time	F		1	-9.2879	14.2404	63	-0.65	0.5166
Gender*time	F		2	-16.5809	8.7703	63	-1.89	0.0633
Gender*time	F		3	0	.	.	.	.
Gender*time	M		1	0	.	.	.	.
Gender*time	M		2	0	.	.	.	.
Gender*time	M		3	0	.	.	.	.
x				0.7162	0.09969	63	7.18	<.0001
x*time			1	0.05515	0.1006	63	0.55	0.5856
x*time			2	-0.04048	0.06184	63	-0.65	0.5152
x*time			3	0	.	.	.	.

We find that there is no intercation between time and any of the other 3 predictor variables (however Gender=F and time=2 is very close to significance).

3) Plot a boxplot of residuals for gender. What did you observe?

```
knitr::include_graphics("/Users/ryangallagher/Desktop/MedicalCollegeofWisconsin/BIOS_04232_MM2/SGPlot.png")
```

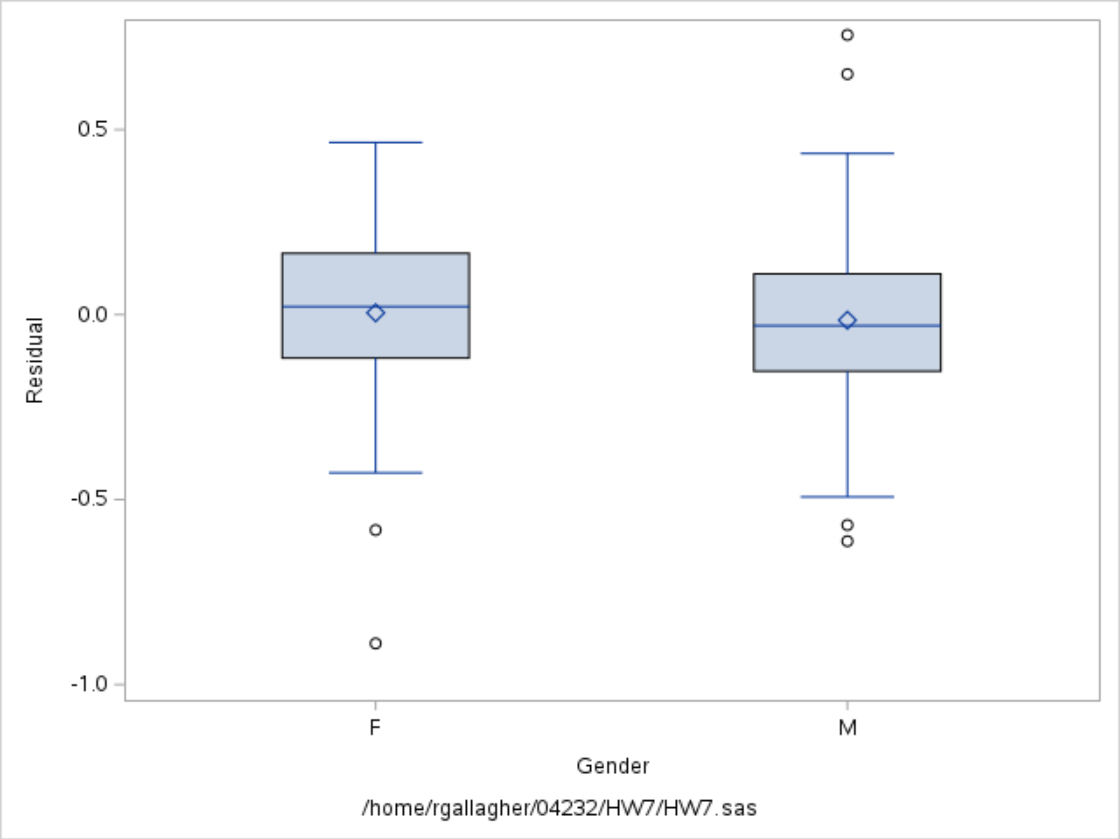


We find that the Female residuals are relatively normal, where the Male residuals are quite skewed (likely as a result of two large outliars)

4) Base on your observation in (3), what is your recommendation? Fit a marginal model based on your recommendation. State your model and assumptions.

I decided to try a log transformation on y. This produces the box plot:

```
knitr::include_graphics("/Users/ryangallagher/Desktop/MedicalCollegeofWisconsin/BIOS_04232_MM2/SGPlot1.png")
```



Here is a marginal model using the SAS code:

```
data grip2;
    set grip;
    y_prime = log(y);
run;

proc mixed data=grip2;
  class trt gender time;
  model y_prime = trt gender time x / ddfm=kr solution residual
outp=residuals2;
  repeated time / type=un subject=subject;
run;
```

Where we get the model:

$$log(y) = 4.34 + 0.0126 * trt_1 + -.2904 * Female + -0.2452 * time_1 + 0.01880 * time_2 + 0.005019 * x$$

And it has the same assumptions as with the untranformed version of this model.

5) Based on your model in (4), test whether time=1 and time=2 are equal.

SAS INPUT:

```
proc mixed data=grip2;
    class trt gender time;
    model y_prime = trt gender time x / ddfm=kr solution;
    repeated time / type=un subject=subject;
    lsmeans time / diff cl;
run;
```

SAS OUTPUT:

```
                    Differences of Least Squares Means

                                    Standard
  Effect  time  _time  Estimate     Error    DF  t Value  Pr > |t|   Alpha

  time    1     2      -0.04332   0.02805  64.2    -1.54    0.1274    0.05
  time    1     3      -0.02452   0.03112  61.3    -0.79    0.4339    0.05
  time    2     3       0.01880   0.02118  57.9     0.89    0.3784    0.05

                    Differences of Least Squares Means

                 Effect  time  _time     Lower       Upper

                 time    1     2      -0.09936     0.01272
                 time    1     3      -0.08675     0.03771
                 time    2     3      -0.02360     0.06120
```

Thus, we see that the difference between time=1 and time=2 are not significantly different since the p_val > 0.05. We can also see that their CI for difference is [-0.09936, 0.01272], which overlaps 0. This means that we cannot confidently say that the difference between time 1 and time 2 isn't 0.