Repeated-Measures ANOVA & Friedman Test Using STATCAL (R) & SPSS

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CONTENT

1.1 Example of Case

For example given data of weight of 11 persons before and after consuming medicine of diet for one week, two weeks, three weeks and four week (Table 1.1.1).

Tabel 1.1.1 Data of Weight of 11 Persons

Name	Weight				
	Before	One Week	Two Weeks	Three Weeks	Four Weeks
A	89.43	85.54	80.45	78.65	75.45
B	85.33	82.34	79.43	76.55	71.35
C	90.86	87.54	85.45	80.54	76.53
D	91.53	87.43	83.43	80.44	77.64
E	90.43	84.45	81.34	78.64	75.43
F	90.52	86.54	85.47	81.44	78.64
G	87.44	83.34	80.54	78.43	77.43
H	89.53	86.45	84.54	81.35	78.43
I	91.34	88.78	85.47	82.43	78.76
J	88.64	84.36	80.66	78.65	77.43
K	89.51	85.68	82.68	79.71	76.5
Average	89.51	85.68	82.68	79.71	76.69

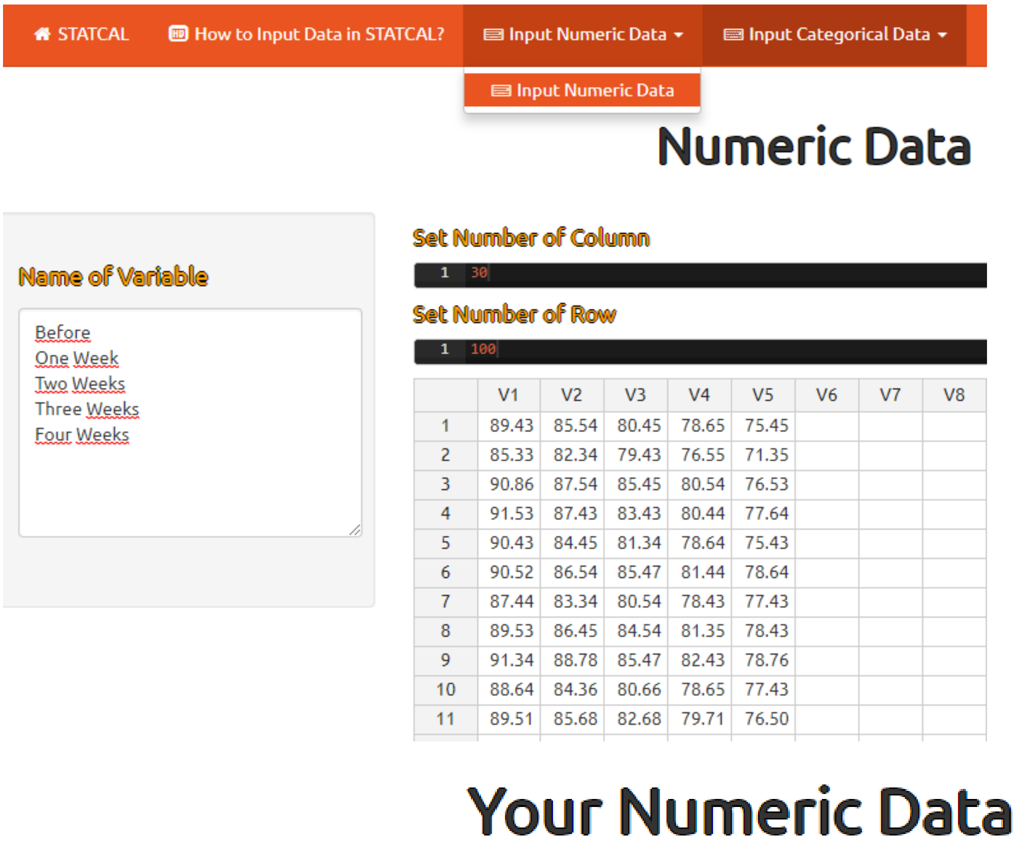
Based on Table 1.1.1:

- ⇨ The person whose name is A has initial weight 89,43, after consuming medicine of diet for one week 85,54, two weeks 80,45, three weeks 78,65 and four weeks 75,45.
- ⇨ On average, there is decreasing of weight before and after consuming medicine of diet.
- ⇨ Repeated-measures ANOVA and Friedman test will be used to test whether there is significant decreasing of weight, before and after consuming medicine of diet?

Data are presented in SPSS (Figure 1.1.1) and STATCAL (Figure 1.1.2).

	Before	One_Week	Two_Weeks	Three_Weeks	Four_Weeks
1	89.43	85.54	80.45	78.65	75.45
2	85.33	82.34	79.43	76.55	71.35
3	90.86	87.54	85.45	80.54	76.53
4	91.53	87.43	83.43	80.44	77.64
5	90.43	84.45	81.34	78.64	75.43
6	90.52	86.54	85.47	81.44	78.64
7	87.44	83.34	80.54	78.43	77.43
8	89.53	86.45	84.54	81.35	78.43
9	91.34	88.78	85.47	82.43	78.76
10	88.64	84.36	80.66	78.65	77.43
11	89.51	85.68	82.68	79.71	76.50

Figure 1.1.1 Data in Table 1.1.1 is Presented in SPSS



	V1	V2	V3	V4	V5	V6	V7	V8
1	89.43	85.54	80.45	78.65	75.45			
2	85.33	82.34	79.43	76.55	71.35			
3	90.86	87.54	85.45	80.54	76.53			
4	91.53	87.43	83.43	80.44	77.64			
5	90.43	84.45	81.34	78.64	75.43			
6	90.52	86.54	85.47	81.44	78.64			
7	87.44	83.34	80.54	78.43	77.43			
8	89.53	86.45	84.54	81.35	78.43			
9	91.34	88.78	85.47	82.43	78.76			
10	88.64	84.36	80.66	78.65	77.43			
11	89.51	85.68	82.68	79.71	76.50			

```
   Before One Week Two Weeks Three Weeks Four Weeks
1   89.43    85.54     80.45       78.65      75.45
2   85.33    82.34     79.43       76.55      71.35
3   90.86    87.54     85.45       80.54      76.53
4   91.53    87.43     83.43       80.44      77.64
5   90.43    84.45     81.34       78.64      75.43
6   90.52    86.54     85.47       81.44      78.64
7   87.44    83.34     80.54       78.43      77.43
8   89.53    86.45     84.54       81.35      78.43
9   91.34    88.78     85.47       82.43      78.76
10  88.64    84.36     80.66       78.65      77.43
11  89.51    85.68     82.68       79.71      76.50
```

Figure 1.1.2 Data in Table 1.1.1 is Presented in STATCAL

1.2 Explanation of Some Book About Repeated-Measures ANOVA

Andy Field (2009:459) in his book "*Discovering Statistics Using SPSS, 3rd Edition*":

"Over the last three chapters we have looked at a procedure ***called ANOVA which is used for testing differences between several means****. So far we've concentrated on situations in which* ***different people contribute to different means****; put another way, different people take part in different experimental conditions. …I've put it off long enough, and now I'm going to take you through what happens when* ***we do ANOVA on repeated-measures data****.*

Repeated-measures is a term used when the same participants participate in all conditions of an experiment."

Andy Field (2009:460) in his book "*Discovering Statistics Using SPSS, 3rd Edition*":

"SPSS produces a test known as ***Mauchly's test****,* ***which tests the hypothesis that the variances of the differences between conditions are equal****."*

Andy Field (2009:479) in his book "*Discovering Statistics Using SPSS, 3rd Edition*":

"➔ The one-way repeated-measures ANOVA compares several means, when those means have come ***from the same participants****; for example, if you measured people's statistical ability each month over a year-long course.*

➔ In repeated-measures ANOVA there is an additional assumption: sphericity. This assumption needs to be considered only when ***you have three or more repeated-measures conditions****.* ***Test for sphericity using Mauchly's test****. Find the table with this label: if the value in the column labelled Sig.* ***is less than .05 then the assumption is violated****. If the significance of Mauchly's test is greater than .05 then* ***the assumption of sphericity has been met****.*

➔ The table labelled ***Tests of Within-Subjects Effects*** *shows the main result of your ANOVA.* ***If the assumption of sphericity has been met then look at the row labelled Sphericity Assumed****. If the* ***assumption was violated then read the row labeled Greenhouse-Geisser*** *(you can also look at Huynh-Feldt but you'll have to read this chapter to find out the relative merits of the two procedures). Having selected the appropriate row, look at the column labelled Sig. if the value is less than .05 then the means of the groups are significantly different.*

➔ For contrasts and post hoc tests, again look to the columns labelled Sig. to discover if your comparisons are significant (they will be if the significance value is less than .05)."

Andy Field (2009:471-472) in his book "*Discovering Statistics Using SPSS, 3rd Edition*":

"Not only does sphericity create problems for the F in repeated-measures ANOVA, but also it causes some amusing complications for post hoc tests (see Jane Superbrain Box 13.2)[5]. If you don't want to worry about what these complications are then the take-home message is that ***when sphericity is violated, the Bonferroni method*** *seems to be generally the* ***most robust of the univariate techniques****, especially in terms of power and control of the Type I error rate. When sphericity is definitely not violated, Tukey's test can be used. In either case, the Games–Howell procedure, which uses a pooled error term, is preferable to Tukey's test."*

Paul H. Kvam and Brani Vidakociv (2007:145) in their book "*Nonparametric Statistics with Applications to Science and Engineering*":

"The Friedman Test is a nonparametric alternative to the randomized block design (RBD) in regular ANOVA. It replaces the RBD when the assumptions of normality are in question or when variances are possibly different from population to population. This test uses the ranks of the data rather than their raw values to calculate the test statistic. Because the Friedman test does not make distribution assumptions, it is not as powerful as the standard test if the populations are indeed normal.

*Milton Friedman published the first results for this test, which was eventually named after him. He received the Nobel Prize for Economics in 1976 and one of the listed breakthrough publications was his article "**The Use of Ranks to Avoid the Assumption of Normality Implicit in the Analysis of Variance**", published in 1937.*

Recall that the RBD design requires repeated measures for each block at each level of treatment. Let X_{ij}, represent the experimental outcome of subject (or "block") i with treatment j, where $i = 1, \ldots, b$, and $j = 1 \ldots . k$."

	Treatments			
Blocks	1	2	...	k
1	X_{11}	X_{12}	...	X_{1k}
2	X_{21}	X_{22}	...	X_{2k}
⋮	⋮	⋮		⋮
b	X_{b1}	X_{b2}	...	X_{bk}

Figure 1.2.1 Book of "*Nonparametric Statistics with Applications to Science and Engineering* (2007:145)"

Andy Field (2009:573) in his book "*Discovering Statistics Using SPSS, 3rd Edition*":

"15.6. Differences between several related groups: Friedman's ANOVA

In Chapter 13 we discovered a technique called one-way related ANOVA that could be used to test for differences between several related groups. Although, as we've seen, ANOVA can be robust to violations of its assumptions, there is another alternative to the repeated-measures case: Friedman's ANOVA (Friedman, 1937). As such, it is used for testing differences between conditions when there are more than two conditions and the same participants have been used in all conditions (each case contributes several scores to the data). If you have violated some assumption of parametric tests then this test can be a useful way around the problem"

Andy Field (2009:577-578) in his book "*Discovering Statistics Using SPSS, 3rd Edition*":

"15.6.5. Post hoc tests for Friedman's ANOVA

*In normal circumstances we wouldn't do any follow-up tests because the overall effect from Friedman's ANOVA was not significant. However, in case you get a result that is significant we will have a look at what options you have. As with the Kruskal–Wallis test, there are two ways to do **non-parametric post hoc procedures, which are in essence the same**. **The first is to use Wilcoxon signed-rank tests** (section 15.4) but correcting for the number of tests we do (see sections 10.2.1 and 15.5.5 for the reasons why). The way we correct for the number of tests is to accept something as significant only if its significance is less than α/number of comparisons (the Bonferroni correction). In the social sciences this usually means .05/number of comparisons. In this example, we have only three groups, so if we compare all of the groups we simply get three comparisons:*

➔ *Test 1: Weight at the start of the diet compared to at one month.*
➔ *Test 2: Weight at the start of the diet compared to at two months.*
➔ *Test 3: Weight at one month compared to at two months.*

Therefore, rather than use .05 as our critical level of significance, we'd use .05/3 = .0167*. In fact we wouldn't bother with post hoc tests at all for this example because the main ANOVA was non-significant, but I'll go through the motions to illustrate what to do.*

The second way to do post hoc tests *is very similar to what we did for the Kruskal–Wallis test in section 15.5.5 and is, likewise, described by Siegel and Castellan (1988). Again, we take the difference between the mean ranks of the different groups and compare these differences to a value based on the value of z (corrected for the number of comparisons being done) and a constant based on the total sample size, N (10 in this example) and the number of conditions, k (3 in this case). The inequality is:*

$$|\bar{R}_u \bar{R}_v| \geq z_{\frac{\alpha}{k(k-1)}} \sqrt{\frac{k(k+1)}{6N}}$$

1.3 Repeated-Measures ANOVA & Friedman Test

Based on explanation at Section 1.2:

- **Repeated-measures ANOVA** can be used to test whether there is significant difference on average based on three or more paired-samples. If there are two paired-samples, so we can use paired-samples t test (parametric approach) or Wilcoxon test (nonparametric approach) (Andy Field, 2009:479-573).
- Paul H. Kvam and Brani Vidakociv (2007:145) Friedman test is an alternative of nonparametric to repeated-measures ANOVA when normality assumption or assumption of equality of variances is not fulfilled. Friedman test uses ranking data rather than raw data to calculate statistic of Friedman test. Therefore, Friedman test does not make assumption of distribution and the power is not stronger than repeated-measures ANOVA if indeed the populations are normal distribution.

1.4 Normality Assumption and Assumption of Equality of Variances (Sphericity)

One of assumption in repeated-measures ANOVA is normality assumption (Andy Field, 2009:479-575), namely samples taken from populations which are normal distribution.

Andy Field (2009:573) Repeated-measures ANOVA still give valid result when occur violence of normality assumption (***meaning that the assumption can be a little violated and still provide valid results***). However, there is an alternative method (nonparametric), namely Friedman test. Beside normality assumption, there is assumption of equality of variances, namely variance of populations for each group are same (***variances of the differences between conditions are equal***). To test assumption of equality of variances, we can use Mauchly test.

1.5 Descriptive Statistics Based On SPSS dan STATCAL (R)

The following result is descriptive statistics based on SPSS and STATCAL.

Table 1.5.1 Descriptive Statistics Based on SPSS

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Before	11	85.33	91.53	89.5055	1.83410
One_Week	11	82.34	88.78	85.6773	1.93315
Two_Weeks	11	79.43	85.47	82.6782	2.30769
Three_Weeks	11	76.55	82.43	79.7118	1.71227
Four_Weeks	11	71.35	78.76	76.6900	2.11696
Valid N (listwise)	11				

Table 1.5.2 Descriptive Statistics Based on STATCAL (R)

Variable	Min	Max	mean	standard deviation (sd)	mean-sd	mean+sd	n
Before	85.33	91.53	89.5055	1.8341	87.6714	91.3396	11
One Week	82.34	88.78	85.6773	1.9331	83.7441	87.6104	11
Two Weeks	79.43	85.47	82.6782	2.3077	80.3705	84.9859	11
Three Weeks	76.55	82.43	79.7118	1.7123	77.9995	81.4241	11
Four Weeks	71.35	78.76	76.69	2.117	74.573	78.807	11

The following graphs based on STATCAL (R) (Figure 1.5.1 and Figure 1.5.2).

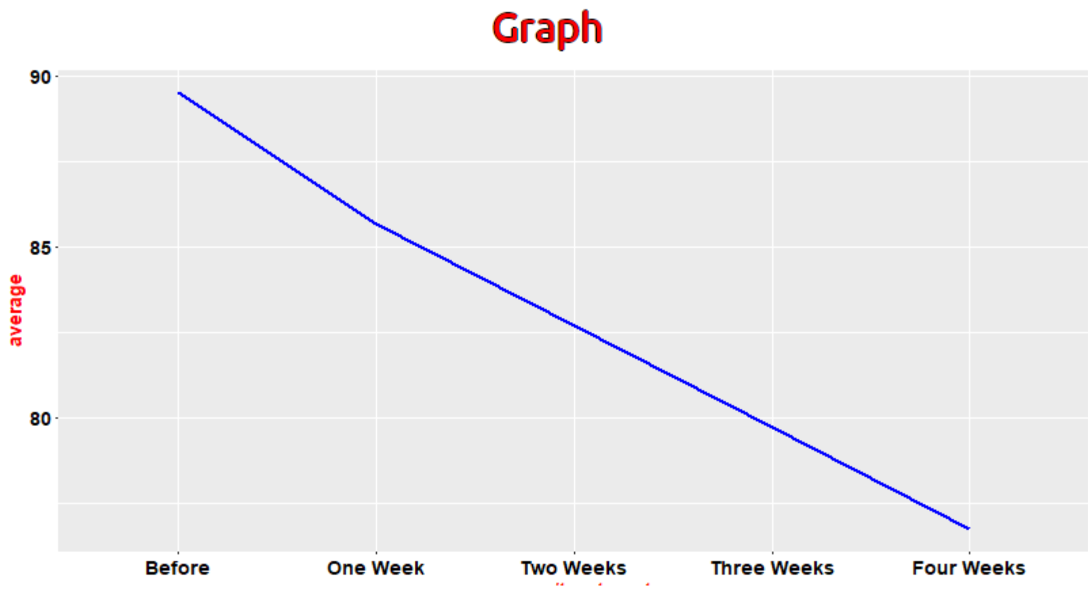


Figure 1.5.1 Average Line Graph Before and After Consuming Medicine of Diet for One, Two, Three and Four Weeks

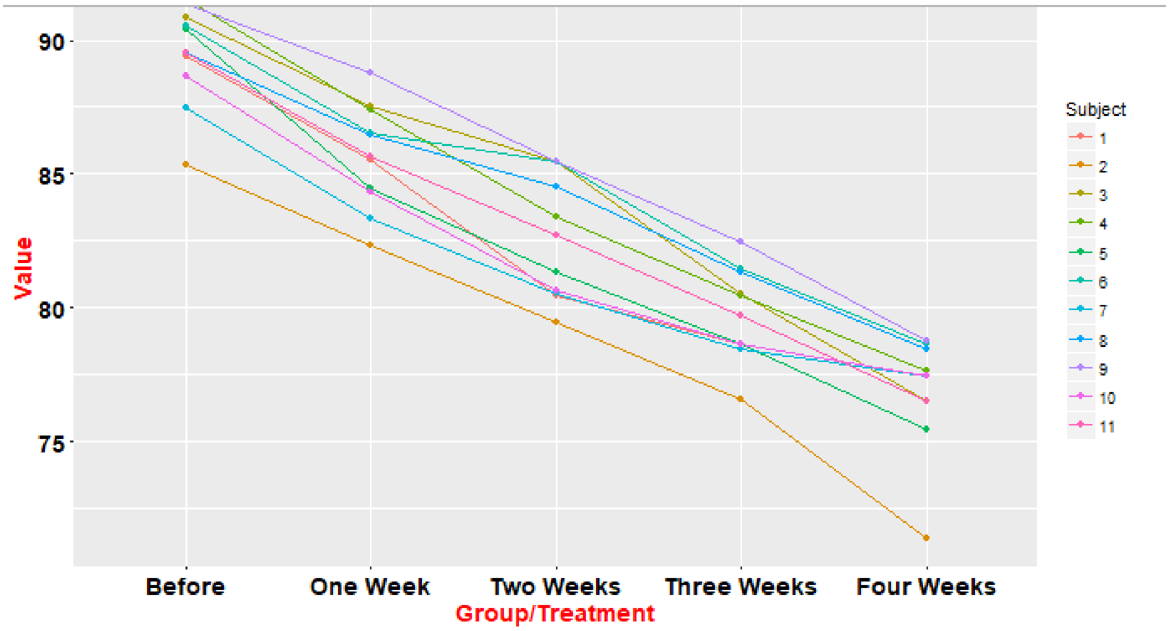


Figure 1.5.2 Line Graph of Weight Based on 11 Persons Before and After Consuming Medicine of Diet for One, Two, Three and Four Weeks

We can see:

⇨ On average, there is reduction of weight, before and after consuming medicine of diet for one week, two weeks, three weeks and four weeks.

⇨ The weight of 10 persons decrease after consuming medicine of diet for one week, two weeks, three weeks and four weeks.

1.6 Normality Assumption Test Using Kolmogorov-Smirnov Test Based on SPSS & STATCAL (R)

The following is result of normality assumption test using Kolmogorov-Smirnov test based on SPSS and STATCAL (R).

Tabel 1.6.1 Result of Normality Assumption Test Using Kolmogorov-Smirnov Test Based on SPSS

One-Sample Kolmogorov-Smirnov Test

		Before	One_Week	Two_Weeks	Three_Weeks	Four_Weeks
N		11	11	11	11	11
Normal Parameters[a,,b]	Mean	89.5055	85.6773	82.6782	79.7118	76.6900
	Std. Deviation	1.83410	1.93315	2.30769	1.71227	2.11696
Most Extreme Differences	Absolute	.211	.110	.174	.187	.192
	Positive	.135	.101	.174	.187	.164
	Negative	-.211	-.110	-.158	-.136	-.192
Kolmogorov-Smirnov Z		.699	.364	.576	.620	.635
Asymp. Sig. (2-tailed)		.712	.999	.895	.837	.815

a. Test distribution is Normal.

b. Calculated from data.

Tabel 1.6.2 Result of Normality Assumption Test Using Kolmogorov-Smirnov Test Based on STATCAL (R)

Variable	Statistic of Kolmogorov-Smirnov (KS)	P-Value of KS	Conclusion	n
Before	0.211	0.712	p-value > 0.05, assumption of normality is received, at the level of significance 5%	11
One Week	0.11	0.999	p-value > 0.05, assumption of normality is received, at the level of significance 5%	11
Two Weeks	0.174	0.895	p-value > 0.05, assumption of normality is received, at the level of significance 5%	11
Three Weeks	0.187	0.837	p-value > 0.05, assumption of normality is received, at the level of significance 5%	11
Four Weeks	0.192	0.815	p-value > 0.05, assumption of normality is received, at the level of significance 5%	11

Based on result of normality test above, we obtain all p-value > level of significance 0,05. So we can conclude that assumption of all samples are taken from normal distribution populations is fulfilled.

1.7 Assumption Test of Equality of Variances Using Mauchly Test Based on SPSS & STATCAL (R)

The following is result of assumption test of equality of variances using Mauchly test based on SPSS and STATCAL (R).

Tabel 1.7.1 Assumption Test of Equality of Variances Using Mauchly Test Based on SPSS

Mauchly's Test of Sphericity[b]

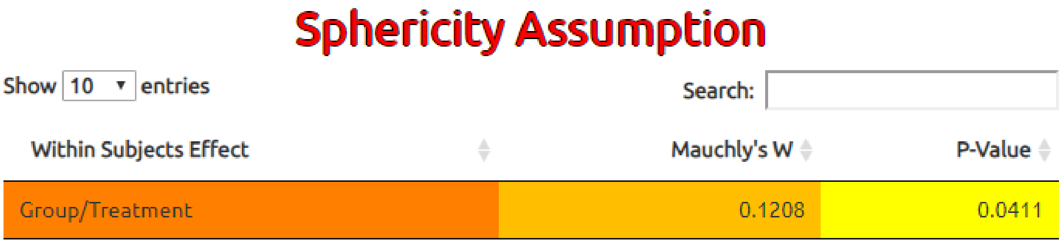
Measure:weight

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	.121	17.793	9	**.041**	.601	.805	.250

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept
Within Subjects Design: time



Sphericity Assumption

Show 10 entries Search:

Within Subjects Effect	Mauchly's W	P-Value
Group/Treatment	0.1208	0.0411

Figure 1.7.1 Assumption Test of Equality of Variances Using Mauchly Test Based on STATCAL

Based on the result above, we obtain p-value (*Sig.*) 0,041 < level of significance 0,05, so we conclude assumption of equality of variances is not fulfilled.

1.8 Repeated-Measures ANOVA Based on SPSS & STATCAL (R)

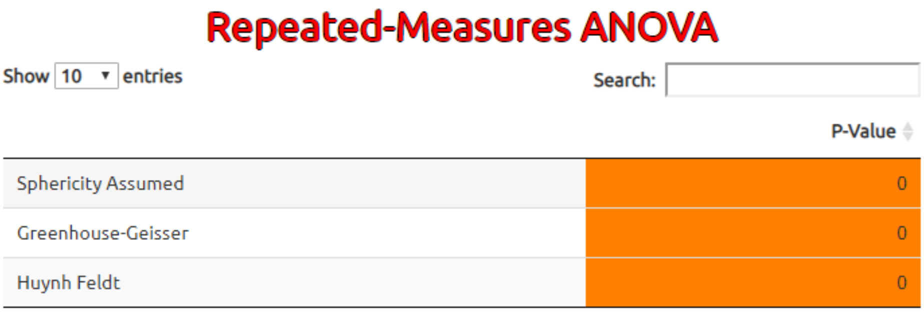
The following is result of repeated-measures ANOVA based on SPSS and STATCAL (R).

Table 1.8.1 Repeated-Measures ANOVA Based on SPSS

Tests of Within-Subjects Effects

Measure:weight

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
time	Sphericity Assumed	1101.230	4	275.308	330.999	.000
	Greenhouse-Geisser	**1101.230**	**2.405**	**457.833**	**330.999**	**.000**
	Huynh-Feldt	1101.230	3.220	341.948	330.999	.000
	Lower-bound	1101.230	1.000	1101.230	330.999	.000
Error(time)	Sphericity Assumed	33.270	40	.832		
	Greenhouse-Geisser	33.270	24.053	1.383		
	Huynh-Feldt	33.270	32.205	1.033		
	Lower-bound	33.270	10.000	3.327		



Repeated-Measures ANOVA

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	P-Value
Sphericity Assumed	0
Greenhouse-Geisser	0
Huynh Feldt	0

Figure 1.8.1 Repeated-Measures ANOVA Based on STATCAL (R)

Field (2009:479):

- ⇨ If assumption of equality of variances (sphericity assumption) is fulfilled, we consider the result in **Sphericity Assumed.**
- ⇨ If assumption of equality of variances (sphericity assumption) is not fulfilled, we consider the result in **Greenhouse-Geisser.**

Because of assumption of equality of variances is not fulfilled, so we consider result **Greenhouse-Geisser**. We obtain p-value of **Greenhouse-Geisser** 0,000 < level of significance 0,05, so there is significant difference of weight before and after consuming medicine of diet for one week, two weeks, three weeks and four weeks.

1.9 Multiple Comparison Test Using Boferroni Test Based on SPSS & STATCAL (R)

Andy Field (2009:471-472) in his book "*Discovering Statistics Using SPSS, 3rd Edition*":

*"Not only does sphericity create problems for the F in repeated-measures ANOVA, but also it causes some amusing complications for post hoc tests (see Jane Superbrain Box 13.2)[5]. If you don't want to worry about what these complications are then the take-home message is that **when sphericity is violated, the Bonferroni method** seems to be generally the **most robust of the univariate techniques**, especially in terms of power and control of the Type I error rate. When sphericity is definitely not violated, Tukey's test can be used. In either case, the Games–Howell procedure, which uses a pooled error term, is preferable to Tukey's test."*

The following is result of multiple comparison test using Bonferroni test based on SPSS & STATCAL (R).

Table 1.9.1 Multiple Comparison Test Using Bonferroni Test Based on SPSS

Pairwise Comparisons

Measure:weight

(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
1	2	3.828*	.272	.000	2.854	4.802
	3	6.827*	.458	.000	5.189	8.466
	4	9.794*	.337	.000	8.587	11.000
	5	12.815*	.480	.000	11.098	14.533
2	1	-3.828*	.272	.000	-4.802	-2.854
	3	2.999*	.327	.000	1.828	4.170
	4	5.965*	.231	.000	5.139	6.792
	5	8.987*	.494	.000	7.217	10.758
3	1	-6.827*	.458	.000	-8.466	-5.189
	2	-2.999*	.327	.000	-4.170	-1.828
	4	2.966*	.271	.000	1.997	3.935
	5	5.988*	.532	.000	4.082	7.895
4	1	-9.794*	.337	.000	-11.000	-8.587
	2	-5.965*	.231	.000	-6.792	-5.139
	3	-2.966*	.271	.000	-3.935	-1.997
	5	3.022*	.353	.000	1.759	4.285
5	1	-12.815*	.480	.000	-14.533	-11.098
	2	-8.987*	.494	.000	-10.758	-7.217
	3	-5.988*	.532	.000	-7.895	-4.082
	4	-3.022*	.353	.000	-4.285	-1.759

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Bonferroni.

Multiple Comparison: Bonferroni

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	Before	One Week	Two Weeks	Three Weeks
One Week	0			
Two Weeks	0	0		
Three Weeks	0	0	0	
Four Weeks	0	0	0	0.0001

Figure 1.9.1 Multiple Comparison Test Using Bonferroni Test Based on STATCAL

Based on the result above:

- ⇨ There significant difference of weight between before and after (one week) (p-value = 0,000 < level of significance 0,05).
- ⇨ There significant difference of weight between before and after (two weeks) (p-value = 0,000 < level of significance 0,05).
- ⇨ There significant difference of weight between before and after (three weeks) (p-value = 0,000 < level of significance 0,05).
- ⇨ There significant difference of weight between before and after (four weeks) (p-value = 0,000 < level of significance 0,05).

- ⇨ There significant difference of weight between after (three weeks) and after (four weeks) (p-value = 0,0001 < level of significance 0,05), etc.

1.10 Friedman Test Based on SPSS & STATCAL (R)

Andy Field (2009:573) Repeated-measures ANOVA still give valid result when occur violence of normality assumption (***meaning that the assumption can be a little violated and still provide valid results***). Friedman test does not need assumption of normality and equality of variances. The following is result of Friedman test based on SPSS and STATCAL (R).

Tabel 1.10.1 Friedman Test Using SPSS

Test Statistics[a]

N	11
Chi-Square	44.000
df	4
Asymp. Sig.	.000

a. Friedman Test

Friedman Test

Choose Variable | Result

Show 10 entries Search:

	Result of Fridman Test
Statistic of Friedman	44
Degree of Freedom	4
Chi-Square Critical Value	9.4877
P-Value	p-value < 0.0001

Figure 1.10.1 Friedman Test Using STATCAL

Based on Friedman result above, we obtain p-value 0,000 < level of significance 0,05, so there is significant difference of weight before and after consuming medicine of diet for one week, two weeks, three weeks and four weeks.

1.11 Multiple Comparison Test Using Wilcoxon Test Based on SPSS & STATCAL (R)

Andy Field (2009:577-578) in his book "*Discovering Statistics Using SPSS, 3rd Edition*":

"15.6.5. Post hoc tests for Friedman's ANOVA

*In normal circumstances we wouldn't do any follow-up tests because the overall effect from Friedman's ANOVA was not significant. However, in case you get a result that is significant we will have a look at what options you have. As with the Kruskal–Wallis test, there are two ways to do **non-parametric post hoc procedures, which are in essence the same**. **The first is to use Wilcoxon signed-rank tests** (section 15.4) but correcting for the number of tests we do (see sections 10.2.1 and 15.5.5 for the reasons why). The way we correct for the number of tests is to accept something as significant only if its significance is less than α/number of comparisons (the Bonferroni correction). In the social sciences this usually means .05/number of comparisons. In this example, we have only three groups, so if we compare all of the groups we simply get three comparisons:*

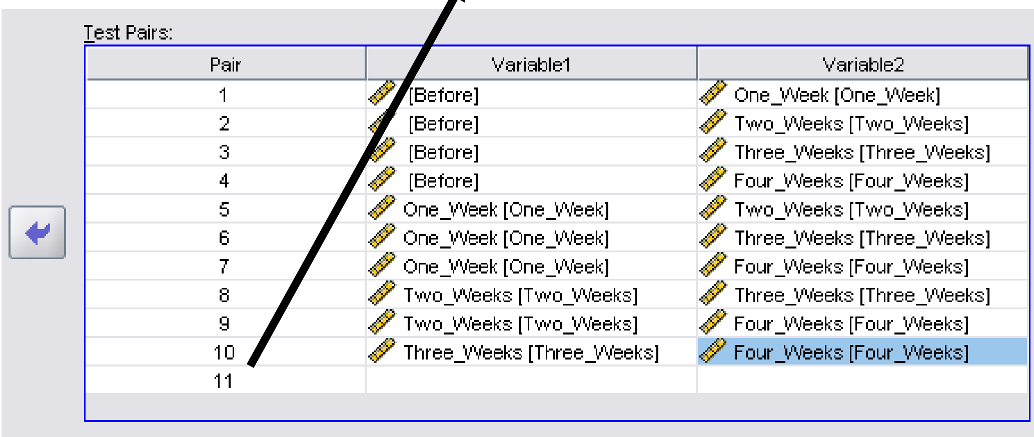
- ➔ *Test 1: Weight at the start of the diet compared to at one month.*
- ➔ *Test 2: Weight at the start of the diet compared to at two months.*
- ➔ *Test 3: Weight at one month compared to at two months.*

***Therefore, rather than use .05 as our critical level of significance, we'd use .05/3 = .0167**. In fact we wouldn't bother with post hoc tests at all for this example because the main ANOVA was non-significant, but I'll go through the motions to illustrate what to do.*

Andy Field (2009:577-578) Wilcoxon test can be used for multiple comparison test as the next test of Friedman test with the little correction of level of significance. The correction of level of significance can be calculated with formula

$$level\ of\ significance\ after\ correction = \frac{initial\ of\ level\ of\ significance}{number\ of\ comparison}$$

$$= \frac{0.05}{10} = 0{,}005$$



Test Pairs:

Pair	Variable1	Variable2
1	[Before]	One_Week [One_Week]
2	[Before]	Two_Weeks [Two_Weeks]
3	[Before]	Three_Weeks [Three_Weeks]
4	[Before]	Four_Weeks [Four_Weeks]
5	One_Week [One_Week]	Two_Weeks [Two_Weeks]
6	One_Week [One_Week]	Three_Weeks [Three_Weeks]
7	One_Week [One_Week]	Four_Weeks [Four_Weeks]
8	Two_Weeks [Two_Weeks]	Three_Weeks [Three_Weeks]
9	Two_Weeks [Two_Weeks]	Four_Weeks [Four_Weeks]
10	Three_Weeks [Three_Weeks]	Four_Weeks [Four_Weeks]
11		

Figure 1.11.1 Number of Comparison is 10

The following is result of Wilcoxon test based on SPSS and STATCAL.

Table 1.11.1 Multiple Comparison Test Using Wilcoxon Test Based on SPSS

Test Statistics[b]

	One_Week - Before	Two_Weeks - Before	Three_Weeks - Before	Four_Weeks - Before	Two_Weeks - One_Week	Three_Weeks - One_Week	Four_Weeks - One_Week	Three_Weeks - Two_Weeks	Four_Weeks - Two_Weeks	Four_Weeks - Three_Weeks
Z	-2.936[a]	-2.934[a]	-2.934[a]	-2.936[a]	-2.934[a]	-2.936[a]	-2.934[a]	-2.934[a]	-2.934[a]	-2.937[a]
Asymp. Sig. (2-tailed)	.003	.003	.003	.003	.003	.003	.003	.003	.003	.003

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Multiple Comparison: Wilcoxon Test

Method:

○ Exact ◉ Asymptotic

Show 10 ▾ entries Search:

	Before	One Week	Two Weeks	Three Weeks	Four Weeks
Before		0.00333	0.00335	0.00335	0.00333
One Week			0.00335	0.00333	0.00335
Two Weeks				0.00335	0.00335
Three Weeks					0.00331
Four Weeks					

Figure 1.11.2 Multiple Comparison Test Using Wilcoxon Test Based on STATCAL

Based on the result above:

- ⇨ There significant difference of weight between before and after (one week) (p-value = 0,00333 < corrected level of significance 0,005).
- ⇨ There significant difference of weight between before and after (two weeks) (p-value = 0,00335 < corrected level of significance 0,005), etc.

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