

Statistics Kingdom

[Home](#) > [Mean tests](#) > One-Way ANOVA

ANOVA Calculator

One-Way ANOVA Calculator and Tukey HSD

[Tutorial ANOVA](#)

Calculators

[Kruskal-Wallis test](#)

[Two way ANOVA](#)

[Levene's test](#)

Significance level (α):

0,05

Outliers:

Included

Effect:

Medium

Effect type:

f

Effect Size:

0.25

Rounding:

4

- ☒ Enter raw data directly
- ☐ Enter raw data from excel

Enter sample data directly

Groups:

Conventional

Assertiveness-based

Data:

177
140
157
122
196
136
179
142
126
169
157
267
192
164
204

154
99
146
107
175
101
129
94
113
136
124
173
174
101
182

Skewness:

3.038603

0.357467

Excess kurtosis:

11.702846

-0.405267

Normality

0.000001938

0.3888

Outliers

267, 429

Mean

170.41379

126.10345

S

60.67273

44.59608

Calculate

Validate

Insert column

Delete column

Clear

Load last run

Header: You may change groups' names to the real names.

Data: When entering data, press **Enter** or **,** (comma) after each value.

You may paste full column from excel.

The calculator ignores empty cells or non-numeric cells.

Group1 contains 29 values

Group2 contains 29 values

validation:success

Hover over the cells for more information.

Source	DF	Sum of Square	Mean Square	F Statistic	P-value
Groups (between groups)	1	28469.3968	28469.3968	10.0421	0.002479
Error (within groups)	56	158759.7243	2834.9951		
Total	57	187229.1211	3284.7214		

[R code.](#)

One Way ANOVA test, using F distribution df(1,56) (right tailed).

1. H_0 hypothesis

Since $p\text{-value} < \alpha$, H_0 is rejected.

Some of the groups' averages consider to be not equal.

In other words, the difference between the averages of some groups is big enough to be statistically significant.

2. P-value

p-value equals **0.00247939**, [$p(x \leq F) = 0.997521$]. It means that the chance of type1 error (rejecting a correct H_0) is small: 0.002479 (0.25%)

The smaller the p-value the stronger it support H_1

3. The statistics

The test statistic F equals **10.042133**, which is not in the 95% region of acceptance: $[-\infty : 4.013]$

https://www.statskingdom.com/180Anova1way.html

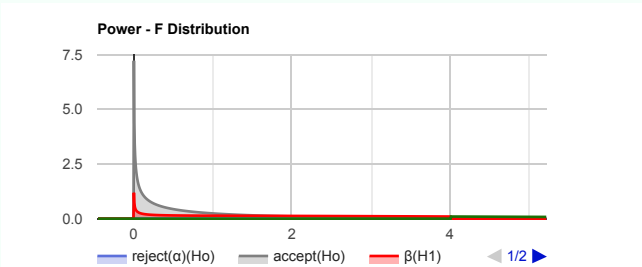
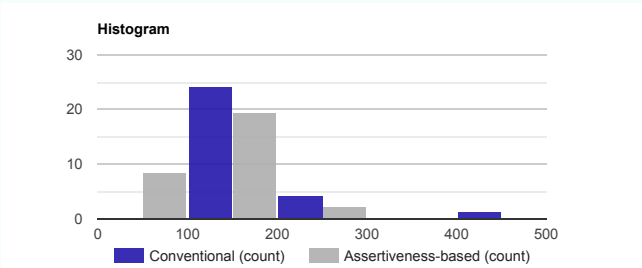
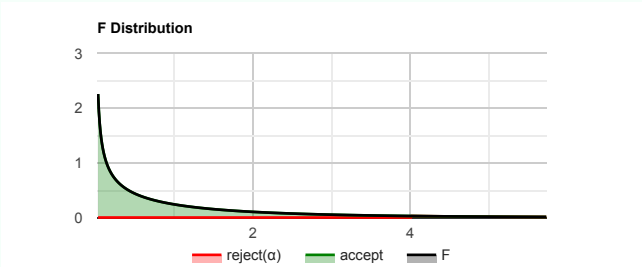
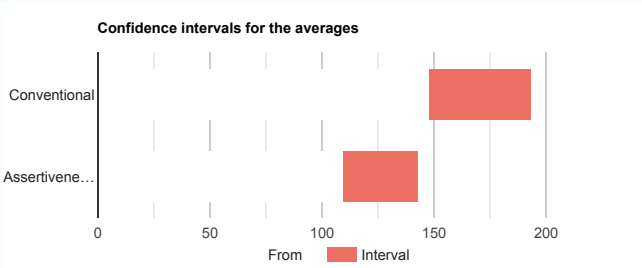
1/3

4. Effect size

The observed effect size f is **large** (0.42). That indicates that the magnitude of the difference between the averages is large.
The η^2 equals 0.15. It means that the **group** explains 15.2% of the variance from the average (similar to R² in the linear regression)

5. Tukey HSD / Tukey Kramer

The means of the following pair are significantly different: **x1-x2**.



Validation

Test power

Although the priori power is low (0.4647), the H₀ is rejected.

Equality of variances

The tool used the Levene's test to assess the equality of variances.
The population's variances consider to be **equal**. (p-value = 0.975).
Levene's test power consider to be weak (0.46).
The groups' size consider similar. (The ratio between the bigger group and the smaller group is: 1)
The ANOVA test consider to be robust to the homogeneity of variances assumption when the groups' sizes are similar.

It is suggested to consider the **Kruskal-Wallis ANOVA**. non-parametric test.

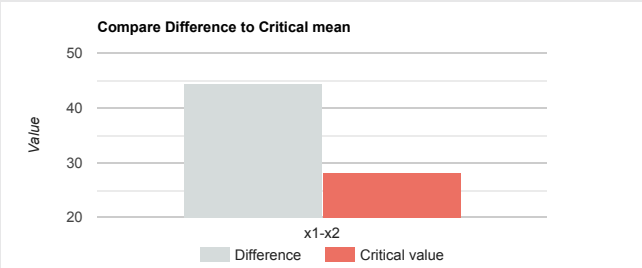
Normality assumption

The assumption was checked based on the [Shapiro-Wilk Test](#). (α=0.05)
The ANOVA test is considered robust for moderate violation of the normality assumption.
From the groups with small sample size, less than 30, **1** group doesn't distribute normally (p-value is 0.00000194).
You should consider transform the data or use the Kruskal–Wallis non-parametric test.

Tukey HSD / Tukey Kramer

Pair	Difference	SE	Q	Lower CI	Upper CI	Critical Mean	p-value
x1-x2	44.3103	9.8873	4.4815	16.2996	72.3211	28.0108	0.002479

Group	x2
x1	44.31



What is the ANOVA?

The ANOVA test checks if the difference between the averages of two or more groups is significant, using sample data.

ANOVA is usually used when there are at least three groups since for two groups, the *two-tailed* pooled variance t-test and the *right-tailed* ANOVA test have the same result.

The basic ANOVA test contains only one categorical value, one-way ANOVA. For example, if you compare the performance of three schools, the categorical variable is school, and the possible values of the categorical variable are School-A, School-B, School-C. There are more complex ANOVA tests that contain two categorical variables ([Two-way ANOVA calculator](#)), or more. When performing a one-way ANOVA test, we try to determine if the difference between the averages reflects a real difference between the groups, or is due to the random noise inside each group.

The F statistic represents the ratio of the variance between the groups and the variance inside the groups. Unlike many other statistic tests, the smaller the F statistic the more likely the averages are equal.

Example: Compare four fertilizers used in four fields

H₀: The average weight of crops per square meter is equal in all fields.

H₁: At least one field yields a different average per square meter.

Right-tailed, for ANOVA test you can use only the right tail. [Why?](#)

Hypotheses

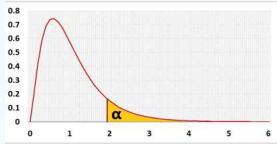
H₀: $\mu_1 = \dots = \mu_k$

H₁: $\text{not}(\mu_1 = \dots = \mu_k)$

ANOVA formula

$$F = \frac{MSG}{MSE}$$

F distribution



Assumptions

- Independent samples
- Normal distribution of the analyzed population
- Equal standard deviation, $\sigma_1=\sigma_2=\dots=\sigma_k$
The assumption is more important when the groups' sizes not similar

Required Sample Data

- Sample data from all compared groups

Parameters

- k** - Number of groups.
- n_i** - Sample side of group i
- n** - Overall sample side, includes all the groups ($\sum n_i$, i=1 to k)
- \bar{x}_i** - Average of group i.
- \bar{x}** - Overall average ($\sum x_{i,j} / n$, i=1 to k, j=1 to n_i)
- S_i** - Standard deviation of group i

Results calculations

Source	Degrees of Freedom	Sum of Squares	Mean Square	F statistic	p-value
Groups (between groups)	$k - 1$	$SSG=\sum_{i=1}^k n_i (\bar{x}_i-\bar{x})^2$	$MSG = SSG / (k - 1)$	$F = MSG / MSE$	$P(x > F)$
Error (within groups)	$n - k$	$SSE=\sum_{i=1}^k (n_i-1) S_i^2$	$MSE = SSE / (n - k)$		
Total	$n - 1$	$SS(\text{total}) = SSG + SSE$	$\text{Sample Variance} = SS(\text{total}) / (n - 1)$		

R Code

The following R code should produce the same results

```
value<-
c(115,120,122,126,129,133,136,138,140,142,144,145,147,151,157,157,162,164,165,169,177,179,192,196,204,208,228,267,429,44,51,78,79,85,94,97,99,101,101,104,107,109,113,114,122,124,129,136,144,146,154,173,174,179)
group1 <- c(rep("Conventional", 29), rep("Assertiveness-based", 29))
my.dataframe<-data.frame(value, group1)
res.aov <- aov(value ~ group1, data = my.dataframe)
summary(res.aov)
TukeyHSD(res.aov)
```