

How to Easily Perform a Three-Way ANOVA in R

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December 1, 2025

RECOMMENDED CITATION

stats writer (2025). *How to Easily Perform a Three-Way ANOVA in R*. PSYCHOLOGICAL SCALES. Retrieved from <https://scales.arabpsychology.com/?p=103407>

In order to perform a Three-Way ANOVA in R, one needs to load the relevant packages, prepare the data, and then use the `aov()` function to specify the response variable, factors and interactions between the factors. Finally, the `summary()` function can be used to view the output of the ANOVA.

A **three-way ANOVA** is used to determine whether or not there is a statistically significant difference between the means of three or more independent groups that have been split on three factors.

The following example shows how to perform a three-way ANOVA in R.

Example: Three-Way ANOVA in R

Suppose a researcher wants to determine if two training programs lead to different mean improvements in jumping height among college basketball players.

The researcher suspects that gender and division (Division I or II) may also affect jumping height so he collects data for these factors as well.

His goal is to perform a three-way ANOVA to determine how training program, gender, and division affect jumping height.

Use the following steps to perform this three-way ANOVA in R:

Step 1: Create the Data

First, let's create a data frame to hold the data:

```
#create dataset
df <- data.frame(program=rep(c(1, 2), each=20),
gender=rep(c('M', 'F'), each=10, times=2),
division=rep(c(1, 2), each=5, times=4),
height=c(7, 7, 8, 8, 7, 6, 6, 5, 6, 5,
5, 5, 4, 5, 4, 3, 3, 4, 3, 3,
6, 6, 5, 4, 5, 4, 5, 4, 4, 3,
2, 2, 1, 4, 4, 2, 1, 1, 2, 1))
```

```
#view first six rows of dataset
```

```
head(df)
```

```
program gender division height
```

```
1 1 M 1 7
```

```
2 1 M 1 7
```

3 1 M 1 8
 4 1 M 1 8
 5 1 M 1 7
 6 1 M 2 6

Step 2: View Descriptive Statistics

Before performing the three-way ANOVA, we can use to quickly summarize the mean jumping height increase grouped by training program, gender, and division:

library(dplyr)

```
#calculate mean jumping height increase grouped by program, gender, and division
df %>%
group_by(program, gender, division) %>%
summarize(mean_height = mean(height))
```

```
# A tibble: 8 x 4
# Groups: program, gender
program gender division mean_height
```

```
1 1 F 1 4.6
2 1 F 2 3.2
3 1 M 1 7.4
4 1 M 2 5.6
5 2 F 1 2.6
6 2 F 2 1.4
7 2 M 1 5.2
8 2 M 2 4
```

Here's how to interpret the output:

The mean jumping height increase among division I females who used training program 1 was **4.6 inches**.

The mean jumping height increase among division II females who used training program 1 was **3.2 inches**.

The mean jumping height increase among division I males who used training program 1 was **7.4 inches**.

And so on.

Step 3: Perform the Three-Way ANOVA

#perform three-way ANOVA

```
model <- aov(height ~ program * gender * division, data=df)
```

```
#view summary of three-way ANOVA
```

```
summary(model)
```

```
Df Sum Sq Mean Sq F value Pr(>F)
program 1 36.1 36.10 65.636 2.98e-09 ***
gender 1 67.6 67.60 122.909 1.71e-12 ***
division 1 19.6 19.60 35.636 1.19e-06 ***
program:gender 1 0.0 0.00 0.000 1.000
program:division 1 0.4 0.40 0.727 0.400
gender:division 1 0.1 0.10 0.182 0.673
program:gender:division 1 0.1 0.10 0.182 0.673
Residuals 32 17.6 0.55
---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The **Pr(>F)** column shows the p-value for each individual factor and the interactions between the factors.

From the output we can see that none of the interactions between the three factors were statistically significant.

We can also see that each of the three factors - program, gender, and division - were statistically significant.

We can now use `dplyr` once again to find the mean jumping height increase for program, gender, and division separately:

library(dplyr)

```
#find mean jumping increase by program
df %>%
group_by(program) %>%
summarize(mean_height = mean(height))
```

```
# A tibble: 2 x 2
```

```
program mean_height
```

```
1 1 5.2
2 2 3.3

#find mean jumping increase by gender
df %>%
group_by(gender) %>%
summarize(mean_height = mean(height))

# A tibble: 2 x 2
gender mean_height
```

```
1 F 2.95
2 M 5.55
```

```
#find mean jumping increase by division
df %>%
group_by(division) %>%
summarize(mean_height = mean(height))
```

```
# A tibble: 2 x 2
division mean_height
```

```
1 1 4.95
2 2 3.55
```

From the output we can observe the following:

The mean jumping height increase among individuals who used training program 1 (**5.2 inches**) was higher than the mean increase among individuals who used training program 2 (**3.3 inches**).

The mean jumping height increase among males (**5.55 inches**) was higher than the mean increase among females (**2.95 inches**).

The mean jumping height increase among division 1 players (**4.95 inches**) was higher than the mean increase among division 2 players (**3.55 inches**).

In conclusion, we would state that training program, gender, and division are all significant predictors of the jumping height increase among players.

We would also state that there are no significant interaction effects between these three factors.

The following tutorials explain how to fit other ANOVA models in R: