

# The Effect of Vitamin C on the Tooth Growth of Guinea Pigs

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*2019-07-16*

## Synopsis

In this project we are going to explore the ToothGrowth data set from the R datasets package and compare the tooth growth of guinea pigs in response to the administration of vitamin C by supplement type and dose via hypothesis tests.

We conclude that the dosage highly affects tooth growth with higher dosage leading to longer teeth ( $p < 0.001$ ) and that the supplement as orange juice is more effective than pure ascorbic acid for small dosages ( $p = 0.002$ ).

## Load libraries

```
library(lattice)
```

## Load the data in R

First we need to load the data. There should be 60 observations of 3 variables as described in the R help page of the ToothGrowth data set obtained by `?ToothGrowth`.

```
data("ToothGrowth")
dim(ToothGrowth)
```

```
## [1] 60  3
```

## Summary of the data

Let's have a quick look at a summary of our data.

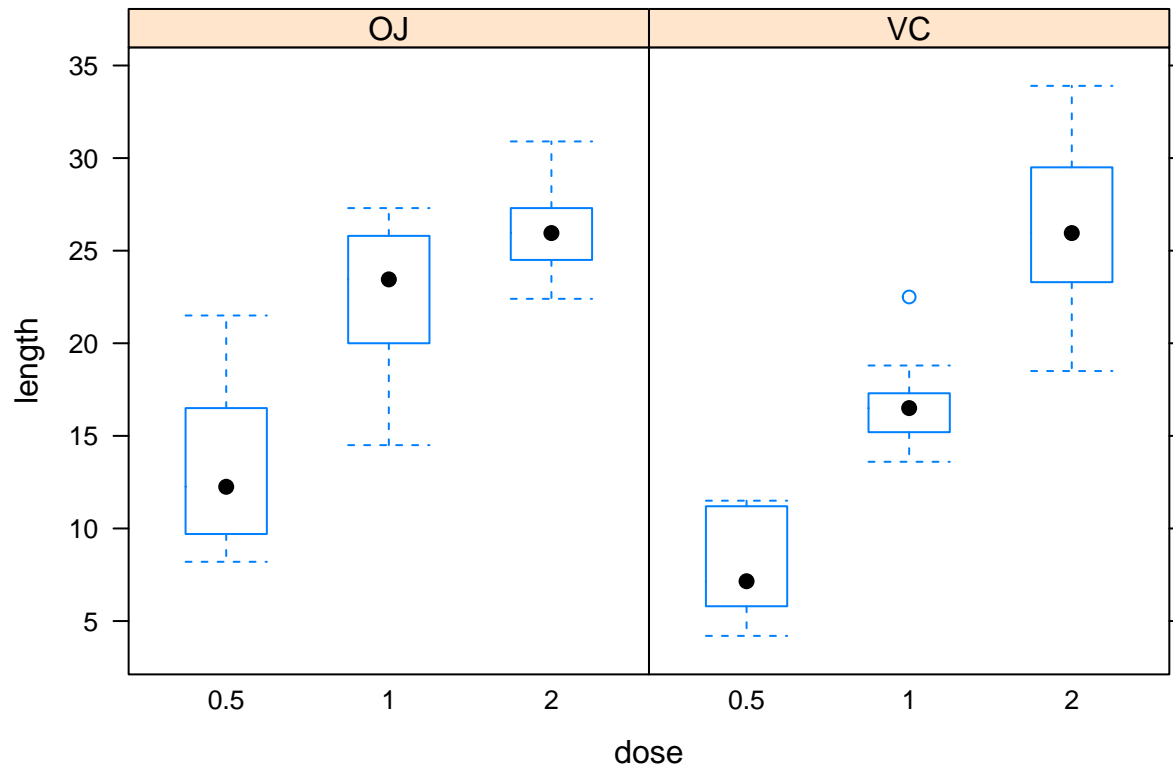
```
summary(ToothGrowth)
```

```
##      len      supp      dose
##  Min.   : 4.20   OJ:30   Min.    :0.500
##  1st Qu.:13.07   VC:30   1st Qu.:0.500
##  Median :19.25             Median :1.000
##  Mean   :18.81             Mean    :1.167
##  3rd Qu.:25.27             3rd Qu.:2.000
##  Max.   :33.90             Max.    :2.000
```

The 60 observations are split into two equally sized groups by the variable `supp`. Lets see how the length of the teeth relate to the dose grouped by the supplement type. We want to look at the dose as a factor. Therefore we add a new column `dosef` to our data before we create our plot.

```
ToothGrowth$dosef <- factor(ToothGrowth$dose)
```

```
bwplot(len ~ dose | supp, data = ToothGrowth, horizontal = F,
       xlab="dose", ylab="length")
```



There is only one outlier in the vitamin C group with 1 mg/day dosage. We can assume that the length of the teeth follows a normal distribution.

With both types of supplement higher dosage seems to mean longer teeth.

The supplement of vitamin C by orange juice seems to lead to longer teeth than with ascorbic acid, but only in lower dosages of 0.5 and 1 mg/day dosages; the difference seems to disappear in a 2 mg/day dosage. Interestingly the variance for the 2 mg/day seems much higher using ascorbic acid.

## Testing our hypotheses

### More vitamin c means longer teeth

We state that a dose of 2 mg/day of vitamin C of either supplement type leads to longer teeth than a dose of 0.5 mg/day or 1 mg/day.  $H_0 : \mu = \mu_0$  vs.  $H_a : \mu > \mu_0$ .

An unpaired, one-sided, two sample t-test is used to check our hypothesis.

```
t.test(ToothGrowth[ToothGrowth$dose > 1,]$len,
       ToothGrowth[ToothGrowth$dose <= 1,]$len,
       alternative="greater")
```

```
##
## Welch Two Sample t-test
##
## data: ToothGrowth[ToothGrowth$dose > 1,]$len and ToothGrowth[ToothGrowth$dose <= 1,]$len
## t = 8.3085, df = 56.202, p-value = 1.173e-11
## alternative hypothesis: true difference in means is greater than 0
```

```
## 95 percent confidence interval:
## 8.729885      Inf
## sample estimates:
## mean of x mean of y
## 26.10      15.17
```

With very high confidence  $p < 0.001$  we can reject the null hypothesis and conclude that a dose of 2 mg/day leads to longer teeth than a dose of 0.5 mg/day.

### Supplement by orange juice leads to longer teeth than pure ascorbic acid

We state that vitamin C supplemented by orange juice leads to longer teeth than pure ascorbic acid if the dose is 0.5 mg/day or 1 mg/day.  $H_0 : \mu = \mu_0$  vs.  $H_a : \mu > \mu_0$ .

Again an unpaired, one-sided, two sample t-test is used to check our hypothesis.

```
t.test(ToothGrowth[ToothGrowth$dose < 2 & ToothGrowth$supp == "OJ"],$len,
       ToothGrowth[ToothGrowth$dose < 2 & ToothGrowth$supp == "VC"],$len,
       alternative="greater")
```

```
##
## Welch Two Sample t-test
##
## data:  ToothGrowth[ToothGrowth$dose < 2 & ToothGrowth$supp == "OJ", and ToothGrowth[ToothGrowth$dose < 2 & ToothGrowth$supp == "VC"],$len
## t = 3.0503, df = 36.553, p-value = 0.002119
## alternative hypothesis: true difference in means is greater than 0
## 95 percent confidence interval:
## 2.497234      Inf
## sample estimates:
## mean of x mean of y
## 17.965      12.375
```

We can safely reject  $H_0$  with  $p = 0.002$  and conclude that the supplement by orange juice is more effective than pure ascorbic acid for smaller dosages under or equal to 1 mg/day.