Effect of Vitamin C on Tooth Growth in Guinea Pigs

Karthik Arumugham

29 April 2016

Overview

The purpose of this data analysis is to analyze the ToothGrowth dataset by formulating several hypothesis for comparing the tooth growth of guinea pigs by supplement and dose.

```
## 'data.frame':    60 obs. of  3 variables:
##  $ len : num  4.2 11.5 7.3 5.8 6.4 10 11.2 11.2 5.2 7 ...
##  $ supp: Factor w/ 2 levels "OJ","VC": 2 2 2 2 2 2 2 2 2 2 ...
##  $ dose: num  0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 ...
```

The dataset has 60 observations, length of odontoblasts (cells responsible for tooth growth) in each of 10 guinea pigs at three dose levels of Vitamin C (0.5, 1 and 2 mg) with two delivery methods (orange juice or ascorbic acid).

```
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
```

Exploratory Analysis

1. **Plot 1**: The tooth lengths seem to be normally distributed.
2. **Plot 2**: There is a large variation and clear seperation in tooth growth for all dose levels of ascorbic acid. But there appears to be clear seperation only for 0.5 and 1 mg/day dose levels of orange juice.

Hypothesis Testing

Hypothesis 1:

- H_0: Mean tooth growth from orange juice is same as ascorbic acid.
- H_1: Mean tooth growth from orange juice is higher.

```
h1<-t.test(len ~ supp, ToothGrowth, paired = F, var.equal = T)
h1$conf.int; h1$p.value
```

```
## [1] -0.1670064  7.5670064
## attr(,"conf.level")
## [1] 0.95
```

```
## [1] 0.06039337
```

The p-value >0.05 and C.I. includes 0. The H_0 cannot be rejected. So orange juice & ascorbic acid seem to deliver the same tooth growth without factoring dose levels.

Hypothesis 2:

- H_0: Mean tooth growth from orange juice is same as ascorbic acid for the dose level of 0.5 mg/day.
- H_1: Mean tooth growth from orange juice is higher for the dose level of 0.5 mg/day.

```
h2<-t.test(len ~ supp, data = subset(ToothGrowth, dose == 0.5), paired = F, var.equal = T)
h2$conf.int; h2$p.value
```

```
## [1] 1.770262 8.729738
## attr(,"conf.level")
## [1] 0.95
```

```
## [1] 0.005303661
```

The p-value is <0.05. The C.I. does not include 0. The H_0 is rejected. So 0.5 mg/day dosage of orange juice seems to deliver more tooth growth than ascorbic acid.

Hypothesis 3:

- H_0: Mean tooth growth from orange juice is same as ascorbic acid for the dose level of 1 mg/day.
- H_1: Mean tooth growth from orange juice is higher for the dose level of 1 mg/day.

```
h3<-t.test(len ~ supp, data = subset(ToothGrowth, dose == 1), paired = F, var.equal = T)
h3$conf.int; h3$p.value
```

```
## [1] 2.840692 9.019308
## attr(,"conf.level")
## [1] 0.95
```

```
## [1] 0.0007807262
```

The p-value is <0.05 and the C.I. does not include 0. The H_0 is rejected. So 1 mg/day dosage of orange juice seems to deliver more tooth growth than ascorbic acid.

Hypothesis 4:

- H_0: Mean tooth growth from orange juice is same as ascorbic acid for the dose level of 2 mg/day.
- H_1: Mean tooth growth from orange juice is higher for the dose level of 2 mg/day.

```
h4<-t.test(len ~ supp, data = subset(ToothGrowth, dose == 2), paired = F, var.equal = T)
h4$conf.int; h4$p.value
```

```
## [1] -3.722999  3.562999
## attr(,"conf.level")
## [1] 0.95
```

```
## [1] 0.9637098
```

The p-value is >0.05 and the C.I. does include 0. H_0 cannot be rejected. So 2 mg/day dosage of orange juice seems to deliver same tooth growth as ascorbic acid.

Hypothesis 5:

- H_0: Mean tooth growth from ascorbic acid (2 mg/day) is same as orange juice (1 mg/day).
- H_1: Mean tooth growth from ascorbic acid (2 mg/day) is higher than orange juice (1 mg/day).

```
temp1 <- rbind(subset(ToothGrowth, (dose == 1) & (supp =="OJ")),
               subset(ToothGrowth, (dose == 2) & (supp =="VC")))
h5<-t.test(len ~ supp, temp1, paired = F, var.equal = T)
h5$conf.int; h5$p.value
```

```
## [1] -7.552325  0.672325
## attr(,"conf.level")
## [1] 0.95
```

```
## [1] 0.09583711
```

The p-value is >0.05 and the C.I. does include 0. The H_0 cannot be rejected. 2 mg/day of ascorbic acid seems to deliver same tooth growth as 1 mg/day of orange juice.

Hypothesis 6:

- H_0: Mean tooth growth from orange juice (2 mg/day) is same as orange juice (1 mg/day).
- H_1: Mean tooth growth from orange juice (2 mg/day) is higher than orange juice (1 mg/day).

```
temp2 <- rbind(subset(ToothGrowth, (dose == 1) & (supp =="OJ")),
               subset(ToothGrowth, (dose == 2) & (supp =="OJ")))
h6<-t.test(len ~ dose, temp2, paired = F, var.equal = T)
h6$conf.int; h6$p.value
```

```
## [1] -6.5005017 -0.2194983
## attr(,"conf.level")
## [1] 0.95
```

```
## [1] 0.0373628
```

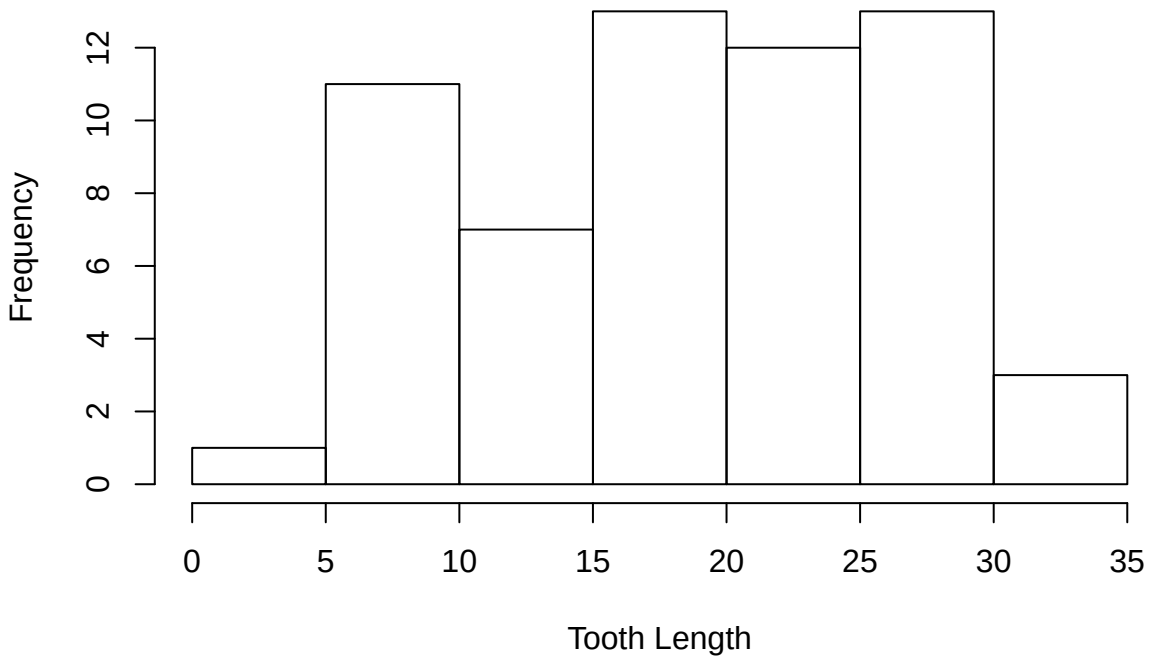
The p-value is <0.05 and the C.I. does not include 0. H_0 is rejected. So 2 mg/day of orange juice seems to deliver higher tooth growth than 1 mg/day.

Conclusion

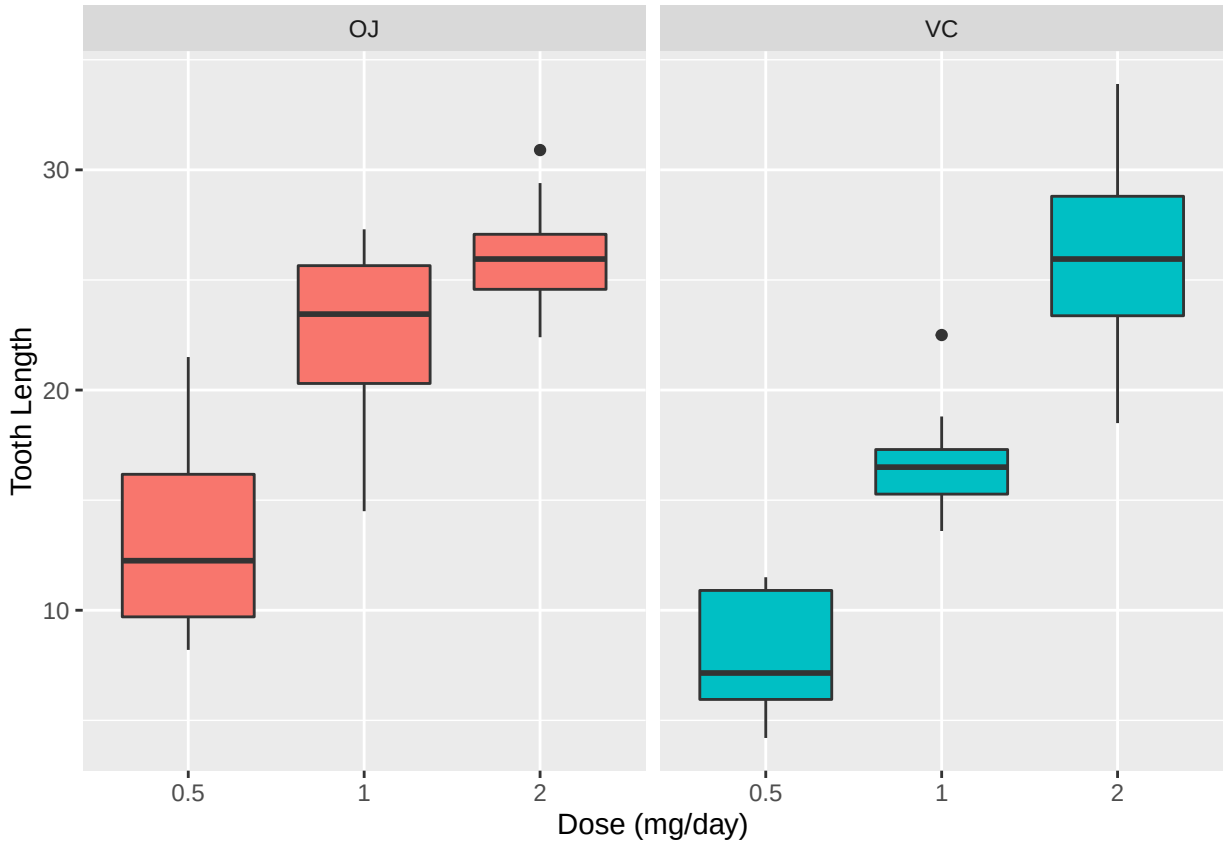
Increase in the dose levels seem to increase the tooth growth. Orange juice is more effective than ascorbic acid for tooth growth when the dosage is 0.5 and 1 mg/day. Both types of supplements are equally as effective when the dose is 2 mg/day. I've assumed there's a common variance in the guinea pigs population (var.equal=TRUE) and that they've used 6 different settings of 10 guinea pigs for the experiment (paired=FALSE) so as not to get biased by an earlier test.

Appendix

Plot 1: Distribution of Tooth Length



Plot 2: Tooth Length vs Supplement and Dose Levels



Plot 3:

```r
qqnorm(ToothGrowth$len); qqline(ToothGrowth$len, col = 2)
```