Examining Vitamin C Effects on Guinea Pig Tooth Growth

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Overview

The following analysis uses the ToothGrowth data in R datasets package. In this data, “len” is the numeric tooth length, “supp” is the supplement type (Orange Juice or ascorbic acid), and “dose” is one of three doses of vitamin C (0.5, 1, and 2 mg/day). The goal is to find statistically significant doses (if any) that create toot growth

Exploratory Analysis

The following graph splits the tooth growth data into two groups: OJ drinkers and ascorbic acid takers to see if there was a difference between the two.

The graph below shows a few things:

1. The group that received dosages in the form of OJ, had more tooth growth
2. At a dosage level of 0.5 mg/day, OJ produced more tooth growth than VC (ascorbic acid)
3. At a dosage level of 1.0 mg/day, OJ produced more tooth growth than VC
4. At a dosage level of 2.0 mg/day, OJ and VC produced approximately the same tooth growth
5. As dosage level increases, the tooth growth also increases

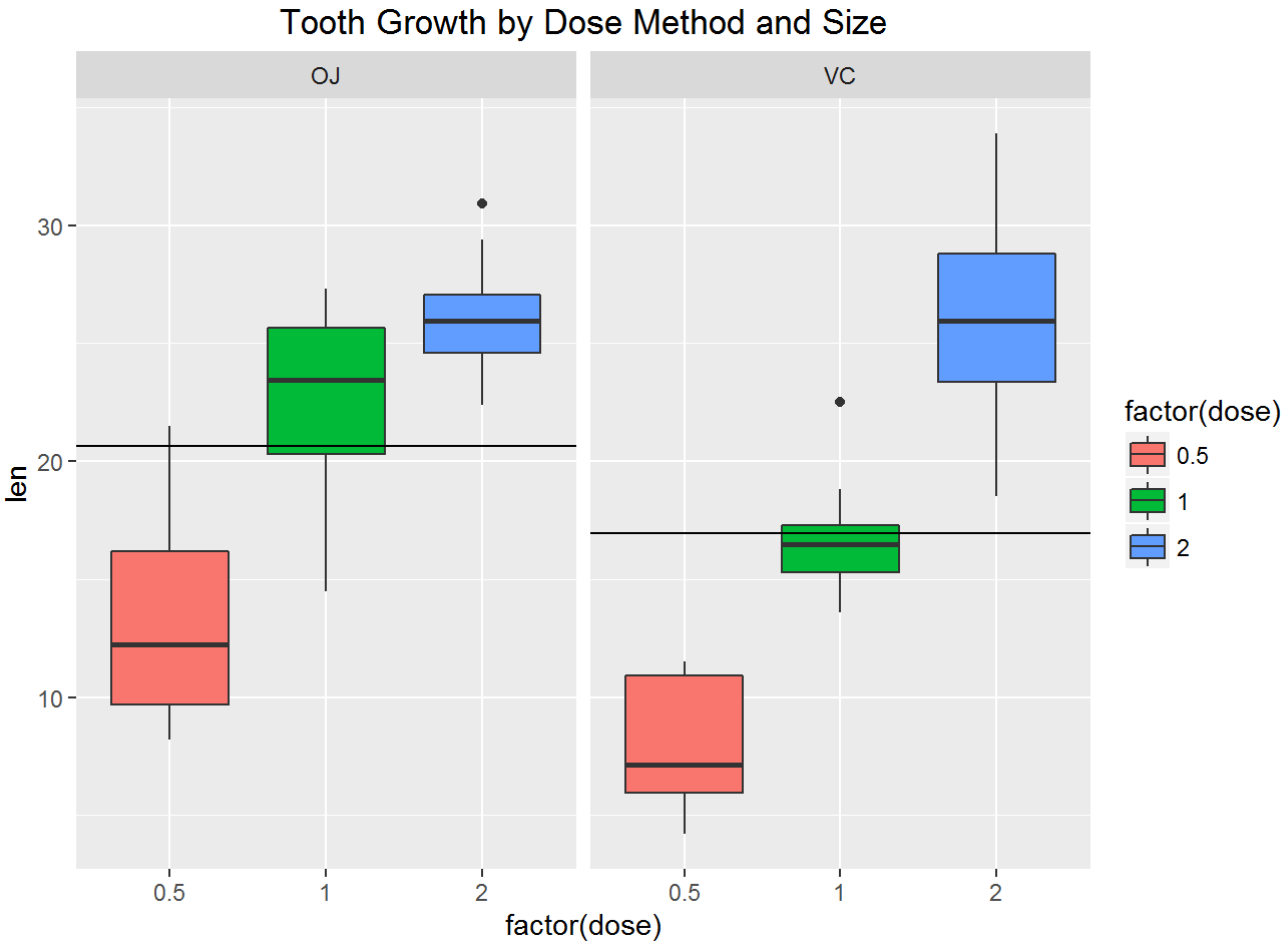
The next question is: are these differences statistically significant?

NOTE: The black lines show the mean for the supplement group as a whole

```
library(datasets)
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 3.3.2
```

```
data(ToothGrowth)
toothmeans<-data.frame(supp=c("OJ","VC"),
                       lenmean=c(mean(ToothGrowth$len[ToothGrowth$supp=="OJ"]),
                                 mean(ToothGrowth$len[ToothGrowth$supp=="VC"])))
#Explore the data
ggplot(ToothGrowth,aes(x=factor(dose),y=len,fill=factor(dose)))+geom_boxplot()+
        facet_grid(.~supp)+
        geom_hline(data = toothmeans,aes(yintercept=lenmean))+
        ggtitle("Tooth Growth by Dose Method and Size")
```



Confidence Interval Testing

In the following sections, hypothesis testing will occur for the five notes listed above, for a total of six hypothesis tests. A 95% confidence level will be used. After seeing fairly symetrical boxplots, it is assumed that the distribution is normal

NOTE: code and output for the six hypothesis tests can be found in the Appendix at the end of this report

Hypothesis Test 1: Did the participants who took OJ have higher tooth growth than the participants that took VC?

The null hypothesis is that the means for the two samples (OJ and VC) are the same.

The alternative hypothesis is: the OJ sample is larger than the VC sample

Because the p-value is less than 0.05, we can conclude that in 95% of samples, any dose of OJ will be more effective than any dose of VC at producing tooth growth

Hypothesis Test 2: At a dose of 0.5 mg/day did the participants who took OJ have higher tooth growth than the participants that took VC?

The null hypothesis is that the means for the two samples (0.5 mg/day of OJ and 0.5 mg/day of VC) are the same.

The alternative hypothesis is: the 0.5 mg/day OJ sample is larger than the 0.5 mg/day VC sample

Because the p-value is less than 0.05, we can conclude that in 95% of samples, a 0.5mg/day dose of OJ will be more effective than a 0.5mg/day dose of VC at producing tooth growth

Hypothesis Test 3: At a dose of 1 mg/day did the participants who took OJ have higher tooth growth than the participants that took VC?

The null hypothesis is that the means for the two samples (1 mg/day of OJ and 1 mg/day of VC) are the same.

The alternative hypothesis is: the 1 mg/day OJ sample is larger than the 1 mg/day VC sample

Because the p-value is less than 0.05, we can conclude that in 95% of samples, a 1mg/day dose of OJ will be more effective than a 1mg/day dose of VC at producing tooth growth

Hypothesis Test 4: At a dose of 2 mg/day did the participants who took OJ have higher tooth growth than the participants that took VC?

The null hypothesis is that the means for the two samples (2 mg/day of OJ and 2 mg/day of VC) are the same.

The alternative hypothesis is: the 2 mg/day OJ sample is larger than the 2 mg/day VC sample

Because the p-value is greater than 0.05, we can conclude that in 95% of samples, a 2mg/day dose of OJ will be more effective than a 2mg/day dose of VC at producing tooth growth

Hypothesis Test 5: Is a 1mg/day dose more effective than a 0.5 mg/day dose?

The null hypothesis is that the means for the two samples (1 mg/day and 0.5 mg/day) are the same.

The alternative hypothesis is: any 1 mg/day sample is larger than any 0.5 mg/day sample

Because the p-value is less than 0.05, we can conclude that in 95% of samples, any 1mg/day dose will be more effective than any 0.5 mg/day dose at producing tooth growth

Hypothesis Test 5: Is a 2mg/day dose more effective than a 1 mg/day dose?

The null hypothesis is that the means for the two samples (2 mg/day and 1 mg/day) are the same.

The alternative hypothesis is: any 2 mg/day sample is larger than any 1 mg/day sample

Because the p-value is less than 0.05, we can conclude that in 95% of samples, any 2mg/day dose will be more effective than any 1 mg/day dose at producing tooth growth

Conclusions

We can conclude that in 95% of samples, the following will be true:

- Any dose size of OJ will be more effective than any dose size of VC

- 0.5mg/day dose of OJ will be more effective than a 0.5mg/day dose of VC at producing tooth growth
- 1 mg/day dose of OJ will be more effective than a 1 mg/day of VC at producing tooth growth.
- Any 1mg/day dose will be more effective than any 0.5 mg/day dose of VC at producing tooth growth
- Any 2mg/day dose will be more effective than any 1 mg/day dose at producing tooth growth

The only alternative hypothesis that we failed to reject was:

- A 2mg/day dose of OJ will be more effective than a 2mg/day dose of VC at producing tooth growth

For the most part, the deliver method and dosage affects tooth growth in guinea pigs. To get the most tooth growth take any 2 mg/day dose of Vitamin C (of either OJ or asorbic acid)

Appendix

Hypothesis Test 1: Did the participants who took OJ have higher tooth growth than the participants that took VC?

```
#95% One-Sided T Test
t.test(ToothGrowth$len[ToothGrowth$supp == "OJ"], ToothGrowth$len[ToothGrowth$supp ==
    "VC"],alternative = "greater")
```

```
##
##  Welch Two Sample t-test
##
## data:  ToothGrowth$len[ToothGrowth$supp == "OJ"] and ToothGrowth$len[ToothGrowth$supp == "V
C"]
## t = 1.9153, df = 55.309, p-value = 0.03032
## alternative hypothesis: true difference in means is greater than 0
## 95 percent confidence interval:
##  0.4682687       Inf
## sample estimates:
## mean of x mean of y
##  20.66333  16.96333
```

Hypothesis Test 2: At a dose of 0.5 mg/day did the participants who took OJ have higher tooth growth than the participants that took VC?

```
#95% One-Sided T Test
t.test(ToothGrowth$len[ToothGrowth$supp == "OJ"&ToothGrowth$dose==0.5],
       ToothGrowth$len[ToothGrowth$supp == "VC"&ToothGrowth$dose==0.5],
       alternative = "greater")
```

```
##
##  Welch Two Sample t-test
##
## data:  ToothGrowth$len[ToothGrowth$supp == "OJ" & ToothGrowth$dose ==  and ToothGrowth$len[To
othGrowth$supp == "VC" & ToothGrowth$dose ==     0.5] and     0.5]
## t = 3.1697, df = 14.969, p-value = 0.003179
## alternative hypothesis: true difference in means is greater than 0
## 95 percent confidence interval:
##  2.34604     Inf
## sample estimates:
## mean of x mean of y
##     13.23      7.98
```

Hypothesis Test 3: At a dose of 1 mg/day did the participants who took OJ have higher tooth growth than the participants that took VC?

```
#95% One-Sided T Test
t.test(ToothGrowth$len[ToothGrowth$supp == "OJ"&ToothGrowth$dose==1],
       ToothGrowth$len[ToothGrowth$supp == "VC"&ToothGrowth$dose==1],
       alternative = "greater")
```

```
##
##  Welch Two Sample t-test
##
## data:  ToothGrowth$len[ToothGrowth$supp == "OJ" & ToothGrowth$dose ==  and ToothGrowth$len[To
othGrowth$supp == "VC" & ToothGrowth$dose ==     1] and     1]
## t = 4.0328, df = 15.358, p-value = 0.0005192
## alternative hypothesis: true difference in means is greater than 0
## 95 percent confidence interval:
##  3.356158      Inf
## sample estimates:
## mean of x mean of y
##     22.70     16.77
```

Hypothesis Test 4: At a dose of 2 mg/day did the participants who took OJ have higher tooth growth than the participants that took VC?

```
#95% One-Sided T Test
t.test(ToothGrowth$len[ToothGrowth$supp == "OJ"&ToothGrowth$dose==2],
       ToothGrowth$len[ToothGrowth$supp == "VC"&ToothGrowth$dose==2],
       alternative = "greater")
```

```
##
##  Welch Two Sample t-test
##
## data:  ToothGrowth$len[ToothGrowth$supp == "OJ" & ToothGrowth$dose ==  and ToothGrowth$len[To
othGrowth$supp == "VC" & ToothGrowth$dose ==     2] and     2]
## t = -0.046136, df = 14.04, p-value = 0.5181
## alternative hypothesis: true difference in means is greater than 0
## 95 percent confidence interval:
##  -3.1335     Inf
## sample estimates:
## mean of x mean of y
##     26.06     26.14
```

Hypothesis Test 5: Is a 1mg/day dose more effective than a 0.5 mg/day dose?

```
#95% One-Sided T Test
t.test(ToothGrowth$len[ToothGrowth$dose==1],
       ToothGrowth$len[ToothGrowth$dose==0.5],
       alternative = "greater")
```

```
##
##  Welch Two Sample t-test
##
## data:  ToothGrowth$len[ToothGrowth$dose == 1] and ToothGrowth$len[ToothGrowth$dose == 0.5]
## t = 6.4766, df = 37.986, p-value = 6.342e-08
## alternative hypothesis: true difference in means is greater than 0
## 95 percent confidence interval:
##  6.753323      Inf
## sample estimates:
## mean of x mean of y
##    19.735    10.605
```

Hypothesis Test 5: Is a 2mg/day dose more effective than a 1 mg/day dose?

```
#95% One-Sided T Test
t.test(ToothGrowth$len[ToothGrowth$dose==2],
       ToothGrowth$len[ToothGrowth$dose==1],
       alternative = "greater")
```

```
##
##  Welch Two Sample t-test
##
## data:  ToothGrowth$len[ToothGrowth$dose == 2] and ToothGrowth$len[ToothGrowth$dose == 1]
## t = 4.9005, df = 37.101, p-value = 9.532e-06
## alternative hypothesis: true difference in means is greater than 0
## 95 percent confidence interval:
##  4.17387     Inf
## sample estimates:
## mean of x mean of y
##    26.100    19.735
```