Effects of Vitamin C on Tooth Length in Guinea Pigs

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Overview

The experiment describes the effects of Vitamin C at 3 dosage levels (0.5, 1, 2 mg/day) and 2 supplement delivery methods (orange juice, ascorbic acid) on tooth length in guinea pigs. There were 10 guinea pigs in each of the six (3 dosage x 2 supplement type) conditions.

Exploratory Analysis

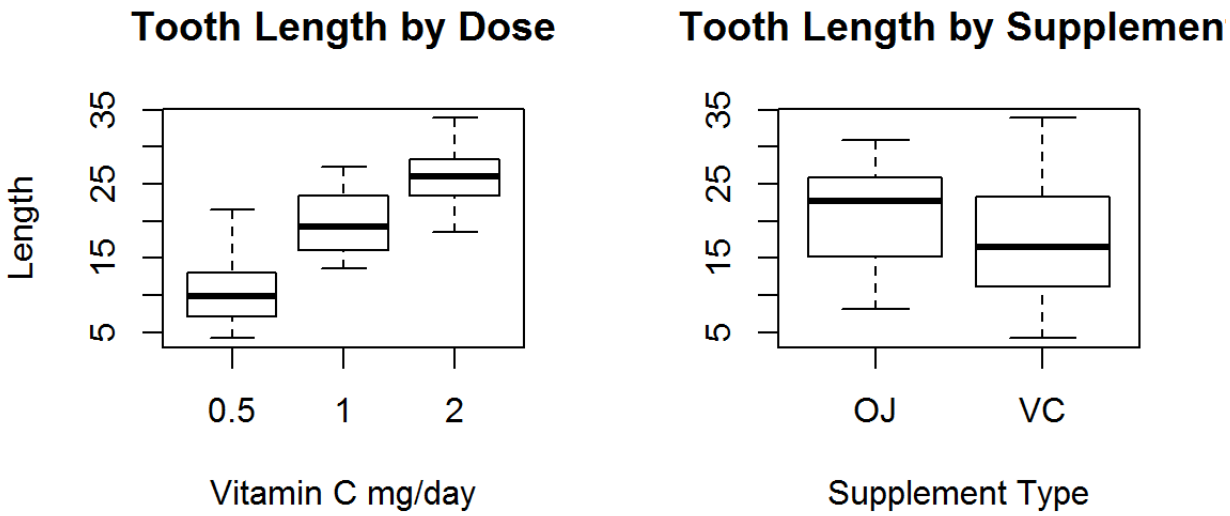
The first step in an exploratory analysis was to determine means and standard deviations for each of the six conditions.

```
data(ToothGrowth)
LengthMeans<-aggregate(ToothGrowth$len,
          by=list(supp=ToothGrowth$supp,dose=ToothGrowth$dose),mean)
names(LengthMeans)[3]<-"Mean"
LengthSD<-aggregate(ToothGrowth$len,
          by=list(ToothGrowth$supp,ToothGrowth$dose),sd)
names(LengthSD)[3]<-"SD"
cbind(LengthMeans, SD=LengthSD$SD)
```

```
##   supp dose  Mean       SD
## 1   OJ  0.5 13.23 4.459709
## 2   VC  0.5  7.98 2.746634
## 3   OJ  1.0 22.70 3.910953
## 4   VC  1.0 16.77 2.515309
## 5   OJ  2.0 26.06 2.655058
## 6   VC  2.0 26.14 4.797731
```

The next step was to average the data across the dosage and supplement variables and plot them, looking for possible main effects of the variables.

```
par(mfcol = c(1,2))
boxplot(ToothGrowth$len ~ ToothGrowth$dose,
        main="Tooth Length by Dose",
        xlab="Vitamin C mg/day",
        ylab="Length")
boxplot(ToothGrowth$len ~ ToothGrowth$supp,
        main="Tooth Length by Supplement",
        xlab="Supplement Type")
```



From these exploratory analyses there appears to be a strong effect of dosage. Whether there is an effect of supplement type is less clear.

Inferential Analysis and Results

We hypothesized that there would be an effect of supplement type (OJ vs. VC) on tooth length, but had no a priori reason to think one supplement type was more effective than the other. For all tests we assumed equal variances in the distribution of the data. A two-tailed t-test was conducted and confidence intervals generated to detect differences based on supplement.

```
supOJVC<-t.test(len ~ supp, data=ToothGrowth, var.equal = TRUE)
```

The means for OJ and VC were 20.7, 17 respectively. The confidence interval for the difference between the means was -0.1670064, 7.5670064. A two-tailed t test was t(58) = 1.915, p-value = 0.0603934. The confidence interval includes a mean difference of 0, and the p-value was greater than .05, so we failed to reject the null hypothesis.

We hypothesized that increased dosages of Vitamin C would increase tooth length. To test the hypothesis, three two-sample tests were conducted: between dosages of 0.5 and 1, 0.5 and 2, and 1 and 2. We ran one-tailed tests because of an a priori belief that dosage positively affects tooth length.

```
dose05.1<-t.test(len ~ dose, data=ToothGrowth[ToothGrowth$dose!=2,], var.equal=TRUE, alternative="less")
dose05.2<-t.test(len ~ dose, data=ToothGrowth[ToothGrowth$dose!=1,], var.equal=TRUE, alternative="less")
dose1.2<-t.test(len ~ dose, data=ToothGrowth[ToothGrowth$dose!=0.5,], var.equal=TRUE, alternative="less")
```

Dose 0.5 vs. Dose 1.0

The means for dose 0.5 and dose 1.0 were 10.6, 19.7 respectively. A one-tailed t test was t(38) = -6.477, p-value = 6.331484810^{-8}.

Dose 0.5 vs. Dose 2.0

The means for dose 0.5 and dose 2.0 were 10.6, 26.1 respectively. A one-tailed t test was t(38) = -11.799, p-value = 6.331484810^{-8}.

Dose 1.0 vs. Dose 2.0

The means for dose 1.0 and dose 2.0 were 19.7, 26.1 respectively. A one-tailed t test was t(38) = -4.9, p-value = 9.054142710^{-6}.

In each case, tooth length increased with dosage, p < .05, so we rejected the null hypothesis in favor of the alternative hypothesis. The study showed that increased doses of Vitamin C increase tooth length in guinea pigs.

Conclusions

Supplement type had no significant effect on tooth growth in guinea pigs, but Vitamin C dosage levels had a significant effect.

Appendix

The output of the t.test function is verbose, so the results were summarized in the main body of the report using R inline coding. The full output of the t-tests are included here for the sake of documentation but are not required for understanding the outcome of the experiment.

```
t.test(len ~ dose, data=ToothGrowth[ToothGrowth$dose!=2,], var.equal=TRUE, alternative="less")
```

```
Two Sample t-test
```

data: len by dose t = -6.4766, df = 38, p-value = 6.331e-08 alternative hypothesis: true difference in means is less than 0 95 percent confidence interval: -Inf -6.753344 sample estimates: mean in group 0.5 mean in group 1 10.605 19.735

```
t.test(len ~ dose, data=ToothGrowth[ToothGrowth$dose!=1,], var.equal=TRUE, alternative="less")
```

```
Two Sample t-test
```

data: len by dose t = -11.799, df = 38, p-value = 1.419e-14 alternative hypothesis: true difference in means is less than 0 95 percent confidence interval: -Inf -13.28093 sample estimates: mean in group 0.5 mean in group 2 10.605 26.100

```
t.test(len ~ dose, data=ToothGrowth[ToothGrowth$dose!=0.5,], var.equal=TRUE, alternative="less")
```

```
Two Sample t-test
```

data: len by dose t = -4.9005, df = 38, p-value = 9.054e-06 alternative hypothesis: true difference in means is less than 0 95 percent confidence interval: -Inf -4.175196 sample estimates: mean in group 1 mean in group 2 19.735 26.100