

Effect of Vitamin C on Tooth Length

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Synopsis

Vitamin C was given to 60 guinea pigs and their tooth length was measured. Each animal received one of three dose levels of vitamin C (0.5, 1, and 2 mg/day) by one of two delivery methods (orange juice OJ or ascorbic acid VC).

In this project we used a series of two sample t-tests to compare tooth length by delivery method and dose. Results were considered statistically significant if $p\text{-value} < 0.05$. We concluded that mean tooth length differed between dose levels, but it did not differ between different vitamin C supplementation delivery modes.

Assumptions Needed for the Analysis

Two-tailed t-test was used to carry out the required comparisons. The following assumptions were made:

- Guinea pigs in the study were sampled independently, i.e. there was no overlap between group members.
- Population variances were unequal.
- Sample size was large enough; hence, by the Central Limit Theorem we could assume that the distribution of the two sample means being tested is approximately Normal.

Exploratory Data Analysis

We loaded the data and transformed the dose variable from numeric to factor to simplify the analysis that follows:

```
library(knitr)

data(ToothGrowth)
str(ToothGrowth)

## '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 ...
## $ dose: num  0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 ...
```

```
# transform dose into a factor
ToothGrowth$dose <- as.factor(ToothGrowth$dose)
```

For each variable, we computed summary statistics (if the variable is continuous) or we looked at each category frequency (if the variable is categorical):

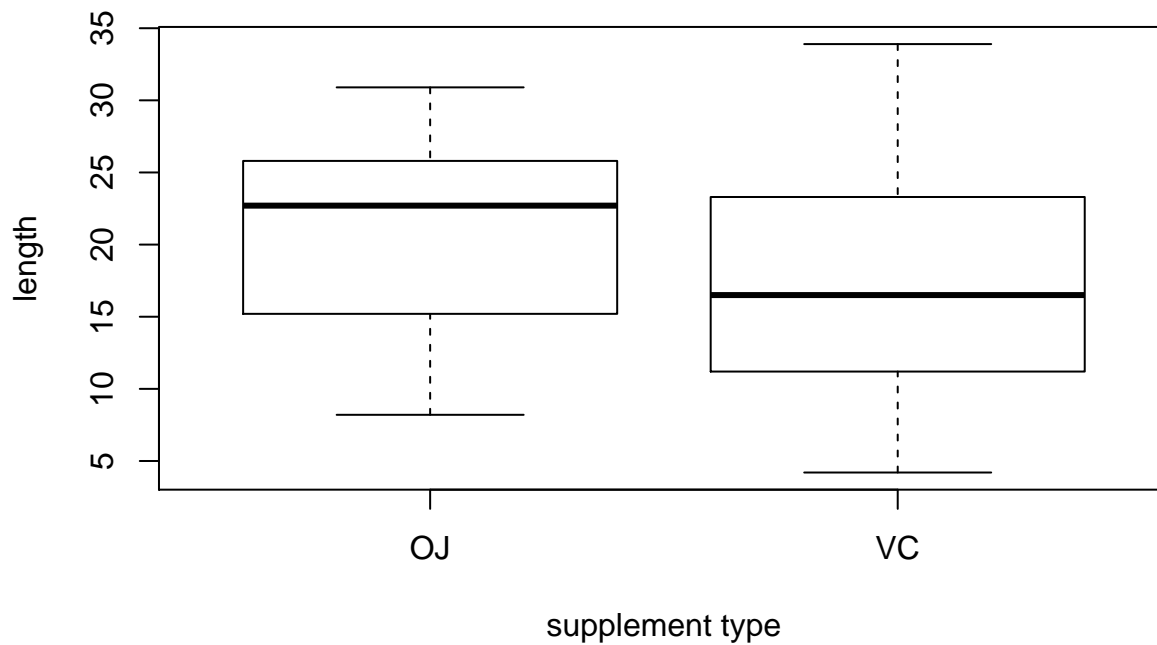
```
summary(ToothGrowth)

##      len      supp      dose
## Min.   : 4.20   OJ:30   0.5:20
## 1st Qu.:13.07   VC:30    1 :20
## Median :19.25           2 :20
## Mean   :18.81
## 3rd Qu.:25.27
## Max.   :33.90
```

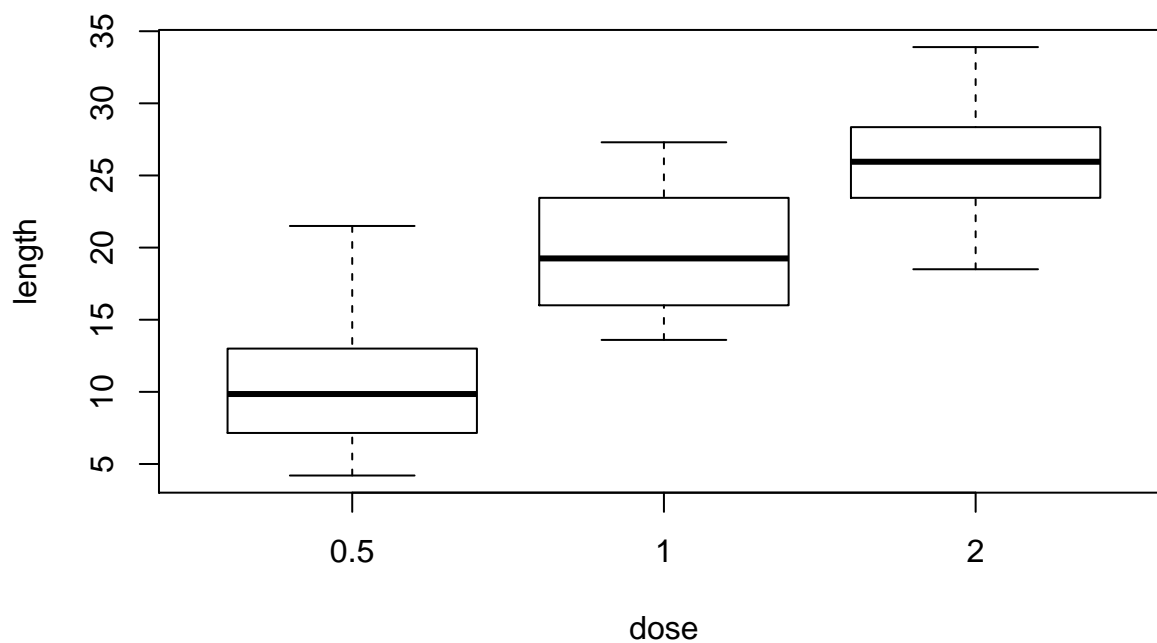
Graphical analysis revealed that median tooth length was higher when vitamin C was delivered through orange juice (OJ), and that tooth length increased with increasing dosage of vitamin C:

```
par(mfrow = c(2,1))
with(ToothGrowth, boxplot(len ~ supp, main = "Tooth Length According to Supplement",
  xlab = "supplement type", ylab = "length"))
with(ToothGrowth, boxplot(len ~ dose, main = "Tooth Length According to Dose",
  xlab = "dose", ylab = "length"))
```

Tooth Length According to Supplement



Tooth Length According to Dose



Results

Tooth Length by Supplement Delivery

We tested whether there is no difference between mean tooth length of guinea pigs whose vitamin C supplementation was delivered through orange juice and mean tooth length of guinea pigs whose vitamin C supplementation was delivered through ascorbic acid:

```
t1 <- with(ToothGrowth, t.test(len ~ supp, var.equal = F))
myvect <- round(c(t1$estimate[1] - t1$estimate[2], t1$conf.int, t1$p.value), 3)
names(myvect) <- c("Estimated Difference", "95%CI Lower Bound", "95%CI Upper Bound", "p-value")
kable(t(myvect), caption = "T-test Results")
```

Table 1: T-test Results

Estimated Difference	95%CI Lower Bound	95%CI Upper Bound	p-value
3.7	-0.171	7.571	0.061

As the p-value is greater than 0.05 we failed to reject the null hypothesis; hence, mean tooth length did not differ between different vitamin C supplementation delivery modes.

Tooth Length by Supplement Dose

As supplement dose had 3 possible levels, we run three separate t-tests to compare two doses at the time. Specifically, the following hypothesis were tested:

1. There is no difference between mean tooth length of guinea pigs who received 0.5 mg of vitamin C and mean tooth length of guinea pigs who received 1 mg of vitamin C.
2. There is no difference between mean tooth length of guinea pigs who received 1 mg of vitamin C and mean tooth length of guinea pigs who received 2 mg of vitamin C.
3. There is no difference between mean tooth length of guinea pigs who received 0.5 mg of vitamin C and mean tooth length of guinea pigs who received 1 mg of vitamin C.

```
# 0.5 vs 1
t1 <- with(subset(ToothGrowth, dose != "2"), t.test(len ~ dose, var.equal = F))
myvect1 <- round(c(t1$estimate[1] - t1$estimate[2], t1$conf.int, t1$p.value), 3)
names(myvect1) <- c("Estimated Difference", "95%CI Lower Bound", "95%CI Upper Bound", "p-value")
# 1 vs 2
t2 <- with(subset(ToothGrowth, dose != "0.5"), t.test(len ~ dose, var.equal = F))
myvect2 <- round(c(t2$estimate[1] - t2$estimate[2], t2$conf.int, t2$p.value), 3)
# 0.5 vs 2
t3 <- with(subset(ToothGrowth, dose != "1"), t.test(len ~ dose, var.equal = F))
myvect3 <- round(c(t3$estimate[1] - t3$estimate[2], t3$conf.int, t3$p.value), 3)
myvect <- rbind(myvect1, myvect2, myvect3)
row.names(myvect) <- c("0.5 vs 1 mg", "1 vs 2 mg", "0.5 vs 2 mg")
kable(myvect, caption = "T-test Results")
```

Table 2: T-test Results

	Estimated Difference	95%CI Lower Bound	95%CI Upper Bound	p-value
0.5 vs 1 mg	-9.130	-11.984	-6.276	0
1 vs 2 mg	-6.365	-8.996	-3.734	0
0.5 vs 2 mg	-15.495	-18.156	-12.834	0

In all three cases, as $p\text{-value} < 0.05$ we rejected the null hypothesis; hence, there was a difference between mean tooth length of guinea pigs depending vitamin C dose received. Looking at the estimated differences and at the 95% confidence intervals in Table 2, we could conclude that increases in vitamin C dose were associated with increased tooth length.

Reference

- Dataset description: <https://stat.ethz.ch/R-manual/R-devel/library/datasets/html/ToothGrowth.html>