Analysis of the effect of vitamin C on tooth growth in guinea pigs

Willy Bakker

Overview

This report provides an analysis of the effect of vitamin C on tooth growth in guinea pigs. More precisely, the impact of the daily dose of vitamin C and the delivery method of vitamin C on tooth growth are analyzed.

The ToothGrowth data of the R package `datasets` were used. These data are from a study conducted in 60 guinea pigs. 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 or ascorbic acid (a form of vitamin C and coded as VC). Subsequently the length of odontoblasts (cells responsible for tooth growth) was measured.

The data frame contains 60 observations on 3 variables:

- `len` - tooth length (microns)
- `supp` - supplement type (OJ or VC)
- `dose` - dose (0.5, 1.0 or 2.0 mg/day)

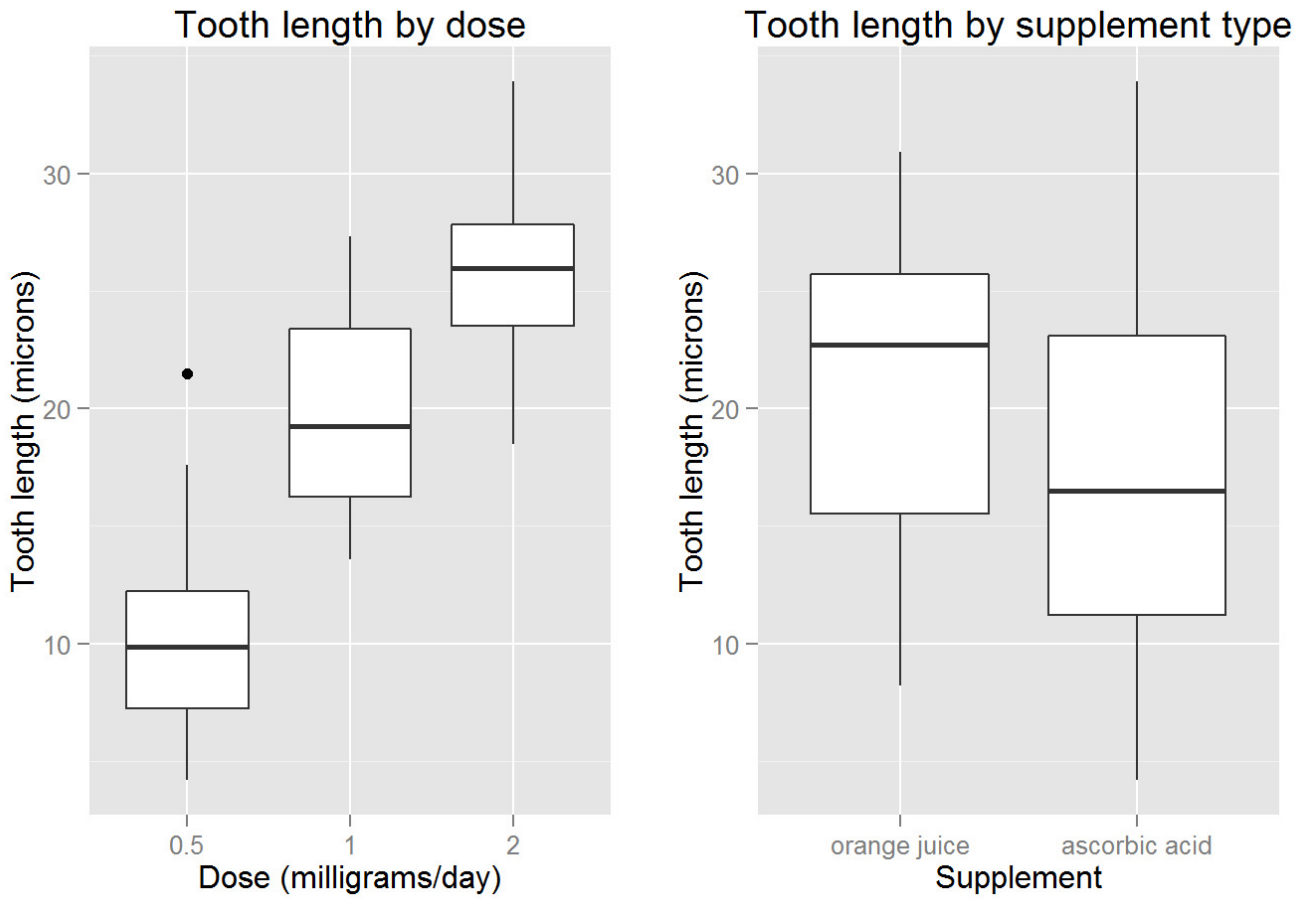
Exploratory data analysis

Table 1 gives a summary of the tooth length of all guinea pigs in the study. The mean tooth length is 18.813 microns with a standard deviation of 7.649 microns. At first sight, the data seem to be normally distributed. The mean and median are quite similar. Also the mininum and maximum are approximately equidistant from the mean. The same goes for the 25% and 75% quantiles.

n	mean	min	q1	median	q3	max	sd
60	18.81333	4.2	13.075	19.25	25.275	33.9	7.649315

Table 1: Summary of the tooth length of guinea pigs in the study

Plot 1 visualizes a summary of the data broken down by daily vitamin C dose and supplement. The average tooth growth in the study increases with higher doses of vitamin C. Also, the average tooth growth in guinea pigs that were administered vitamin c through orange juice is slightly higher than those who received ascorbic acid. The question we need to answer in both cases: Is the difference in tooth length statistically significant?



Plot 1: Tooth grooth by daily dose and supplement type

Hypothesis tests

We assume that the samples in the dose and supplement type groups are random, independent, and come from a normally distributed population with unknow but equal variances. Because the sample size in each group is relatively small, we use Student's t-test for hypothesis testing.

Differences in tooth length between dose levels

We want to test the hypothesis that

- $H_0 : \mu_1 - \mu_0 = 0$
- $H_a : \mu_1 - \mu_0 \neq 0$

and the hypothesis that

- $H_0 : \mu_2 - \mu_1 = 0$
- $H_a : \mu_2 - \mu_1 \neq 0$

and finally the hypothesis that

- $H_0 : \mu_2 - \mu_0 = 0$
- $H_a : \mu_2 - \mu_0 \neq 0$

where μ_0, μ_1 and μ_2 are the population means for dose 0.5, 1.0 and 2.0 mg/day respectively.

For $H_0 : \mu_1 - \mu_0 = 0$ and $H_a : \mu_1 - \mu_0 \neq 0$ the t-based 95% confidence interval is 6.2762523, 11.9837477.

For $H_0 : \mu_2 - \mu_1 = 0$ and $H_a : \mu_2 - \mu_1 \neq 0$ the t-based 95% confidence interval is 3.7356132,

8.9943868.

For $H_0 : \mu_2 - \mu_0 = 0$ and $H_a : \mu_2 - \mu_0 \neq 0$ the t-based 95% confidence interval is 12.836481, 18.153519.

In all cases the value 0 is not included in the confidence interval, thus we reject all three null hypotheses.

Difference in tooth length between supplement types

We want to test the hypothesis that

- $H_0 : \mu_O - \mu_V = 0$
- $H_a : \mu_O - \mu_V \neq 0$

where μ_O and μ_V are the population means for orange juice and ascorbic acid respectively.

For $H_0 : \mu_O - \mu_V = 0$ and $H_a : \mu_O - \mu_V \neq 0$ the t-based 95% confidence interval is -0.1670064, 7.5670064.

The value 0 is included in the confidence interval and thus we accept the null hypothesis.

Conclusions

- The differences in tooth growth between different dose levels of vitamin C are statistically significant.
- The differences in tooth growth between different supplement types are NOT statistically significant.