Investigation of the effect of Vitamin C on tooth growth in guinea pigs depending on dose and delivery method

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5/17/2019

Overview

For this project (Statistical Inference Course Project, Part 2) I will use database ToothGrowth which is a part of R library datasets. There are two delivery methods of vitamin C - orange juice (OJ) or ascorbic acid (VC) and I would like to investigate if one of them has a stronger effect. I can also compare effects of doses because pigs got diffrent doses of vitamin C - 0.5, 1, and 2 mg/day.

Exploratory data analyses

Let's load the data and take a look on it.

```
library(datasets)
data(ToothGrowth)
head(ToothGrowth,4)
```

```
##    len supp dose
## 1  4.2   VC  0.5
## 2 11.5   VC  0.5
## 3  7.3   VC  0.5
## 4  5.8   VC  0.5
```

```
dim(ToothGrowth)
```

```
## [1] 60  3
```

So, there are 60 pigs. We can divide them into 6 groups - depending on delivery method and dose. How many pigs are in each group?

```
library(reshape2)
tmelt <- melt(ToothGrowth,id = c("supp", "dose"),measure.vars = "len")
dcast(tmelt,supp~dose, length)
```

```
##   supp 0.5  1  2
## 1   OJ  10 10 10
## 2   VC  10 10 10
```

There are 10 pigs in each group. And what is the total length for each group?

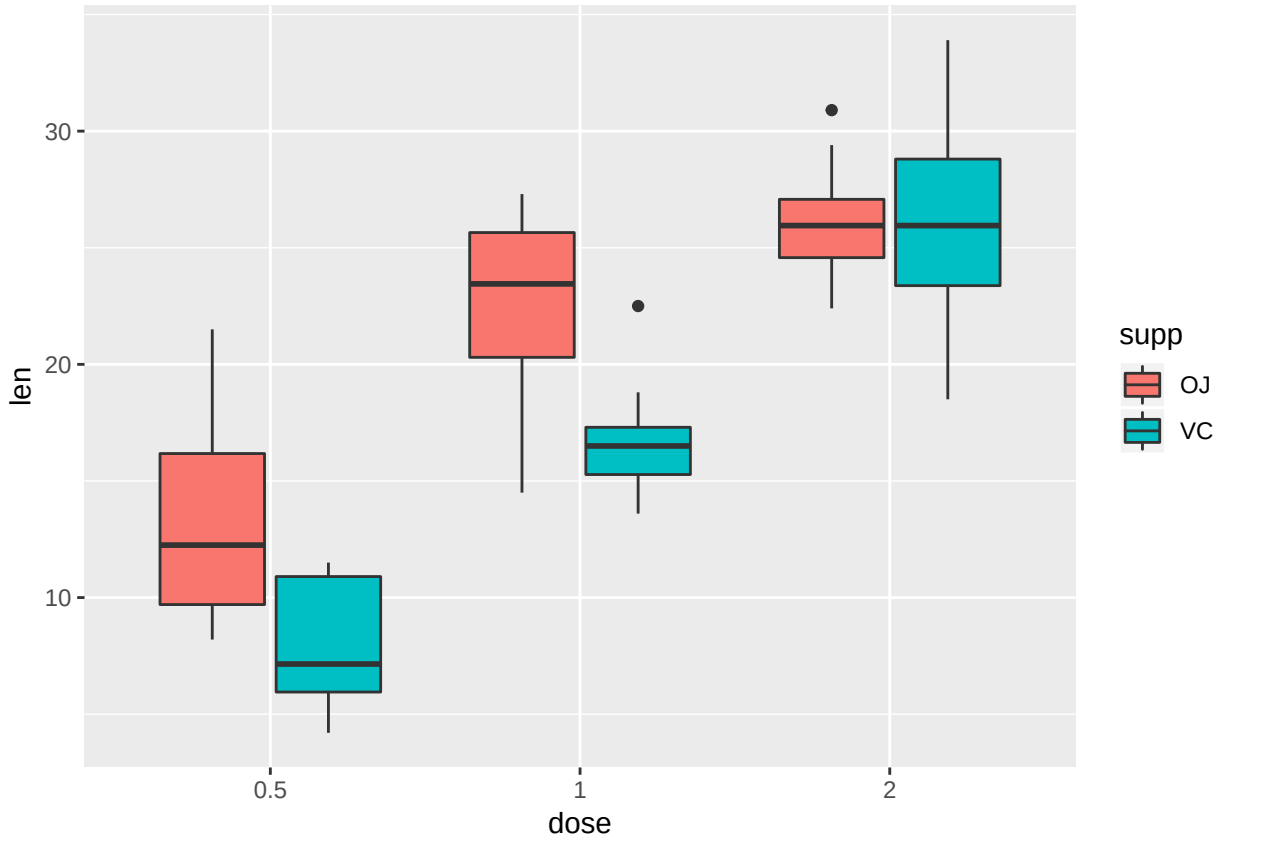
```
dcast(tmelt,supp~dose, sum)
```

```
##   supp   0.5     1     2
## 1   OJ 132.3 227.0 260.6
## 2   VC  79.8 167.7 261.4
```

It seems that tooth's length increases when dose increases. Length for delivery method orange juice is bigger for small doses (0.5, 1) and smaller for dose 2. Now let's plot lengths grouped by delivery method and doses.

```
library(ggplot2)
ToothGrowth2 <- ToothGrowth
ToothGrowth2$dose <- as.factor(ToothGrowth2$dose)
```

```
ggplot(ToothGrowth2, aes(x=dose, y=len, fill=supp)) +
    geom_boxplot()
```



It's shows almost the same hypothesis: length increases when dose increases. Length for delivery method orange juice is bigger for small doses (0.5, 1). Connection between delivery method and tooth's length is unclear for dose 2.

Comparing of tooth growth by supp and dose

I want to test the hypothesis. I assume that data are approximately normally distributed and I can use t test. Let's first divide the lengths into 6 groups:

```
vc05 <- ToothGrowth$len[1:10]
vc1 <- ToothGrowth$len[11:20]
vc2 <- ToothGrowth$len[21:30]
oj05 <- ToothGrowth$len[31:40]
oj1 <- ToothGrowth$len[41:50]
oj2 <- ToothGrowth$len[51:60]
```

Hypothesis 0 (1): the lengths are the same for doses 0.5 and 1

H-alternative: the length for dose 1 is greater than for dose 0.5. I will test it for both delivery methods and look at p-values.

```
t.test(vc1,vc05,paired = FALSE, var.equal = FALSE,alternative = "greater")$p.value
```

```
## [1] 3.405509e-07
```

```
t.test(oj1,oj05,paired = FALSE, var.equal = FALSE,alternative = "greater")$p.value
```

```
## [1] 4.39246e-05
```

P-values are very small, we reject hypopesis 0 (1), so lengths for 1 mg are greater than for 0.5 mg.

Hypothesis 0 (2): the lengths are the same for doses 1 and 2

H-alternative: the length for dose 2 is greater than for dose 1. I will test it for both delivery methods and look at p-values.

```
t.test(vc2,vc1,paired = FALSE, var.equal = FALSE,alternative = "greater")$p.value
```

```
## [1] 4.577802e-05
```

```
t.test(oj2,oj1,paired = FALSE, var.equal = FALSE,alternative = "greater")$p.value
```

```
## [1] 0.01959757
```

P-values are very small, we reject hypopesis 0 (2), so lengths for 2 mg are greater than for 1 mg.

Hypothesis 0 (3): the lengths are the same for both methods when dose is 0.5 and 1 mg

H-alternative: the length for orange juice is greater than for vitamin C. I will test it for both doses and look at p-values.

```
t.test(oj05,vc05,paired = FALSE, var.equal = FALSE,alternative = "greater")$p.value
```

```
## [1] 0.003179303
```

```
t.test(oj1,vc1,paired = FALSE, var.equal = FALSE,alternative = "greater")$p.value
```

```
## [1] 0.0005191879
```

P-values are very small, we reject hypopesis 0 (3), so lengths for orange juice are greater than for vitamin C.

Hypothesis 0 (4): the lengths are the same for both methods when dose is 2 mg

H-alternative: the length for orange juice is less than for vitamin C.

```
t.test(oj2,vc2,paired = FALSE, var.equal = FALSE,alternative = "less")$p.value
```

```
## [1] 0.4819258
```

Wow, p-value equals 0.48, it's quite a lot, we fail to reject the hypothesis (4). Delivery method is not important when we give 2 mg.

Conclusions

If we make an assumption that sample is representative and groups have different variations then we can conclude:

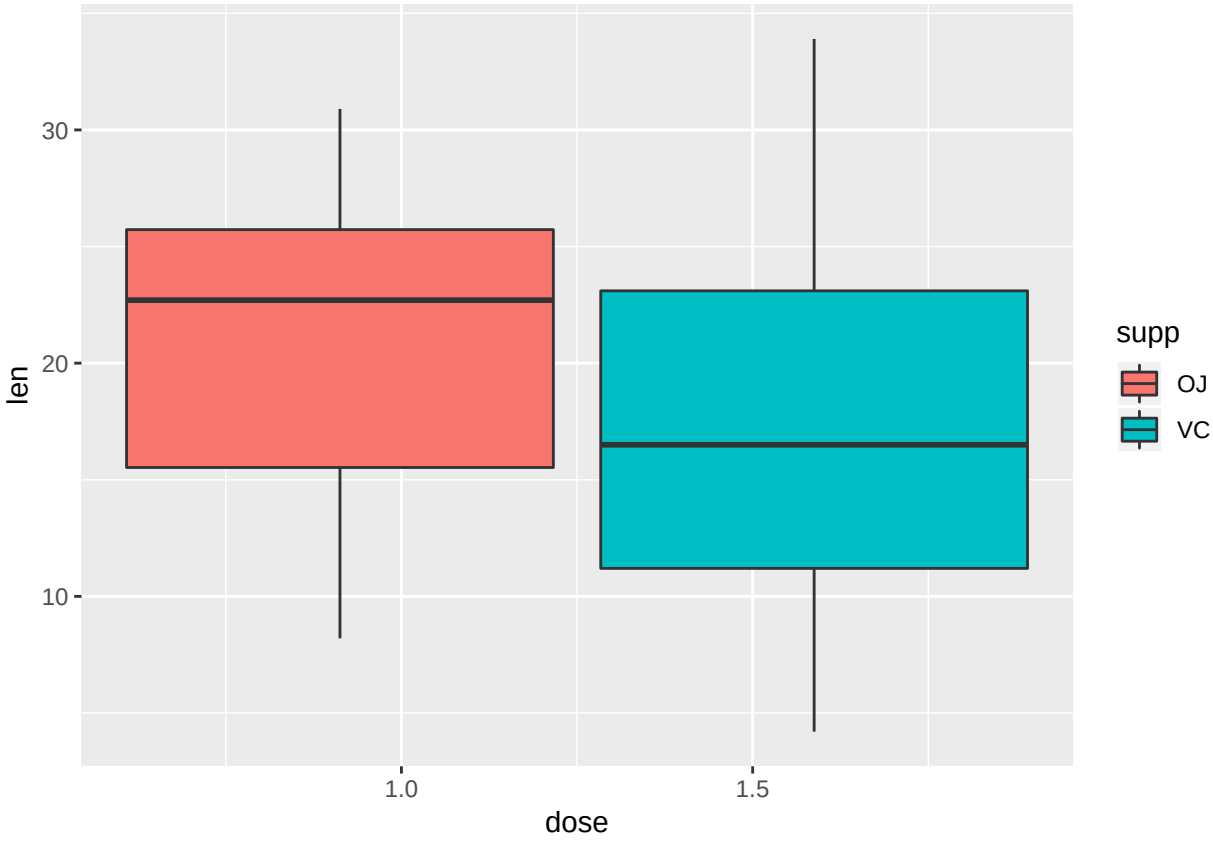
- tooth's length increases when dose increases from 0.5 to 2
- length for delivery method orange juice is bigger than for ascorbic acid for small doses (0.5, 1) and the same for dose 2 mg.

So, if we want teeth to have maximum length we should give pigs 2 mg, delivery method is not important. If we want to give smaller dose - 0.5 or 1 mg and achieve maximum length, we should choose delivery via orange juice.

Appendix

I will also plot all doses together and divide them by delivery methods.

```
library(ggplot2)
ggplot(ToothGrowth, aes(x=dose, y=len, fill=supp)) +
    geom_boxplot()
```



So, the length is bigger for orange juice than for vitamin C for all doses together.