Long in the Tooth

The Effect of Supplements on Guinea Pig Dentoblast Growth

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Summary

The ToothGrowth data set in R shows the length of odontoblasts (tooth cells), in Guinea Pigs after they've been fed orange juice or pure vitamin C. In this analysis, we compare the groups to see whether there are differences in cell length depending on the type or amount of supplement. Our analysis shows that orange juice produces longer odontoblasts and that higher levels of supplement produce longer odontoblasts.

Exploratory Analysis

We begin by putting the ToothGrowth data into a working data frame and examining it by looking at the summary and table of the data set.

```
TG <- ToothGrowth
summary(TG)
```

```
##       len        supp         dose      
##  Min.   : 4.2   OJ:30   Min.   :0.50  
##  1st Qu.:13.1   VC:30   1st Qu.:0.50  
##  Median :19.2           Median :1.00  
##  Mean   :18.8           Mean   :1.17  
##  3rd Qu.:25.3           3rd Qu.:2.00  
##  Max.   :33.9           Max.   :2.00
```

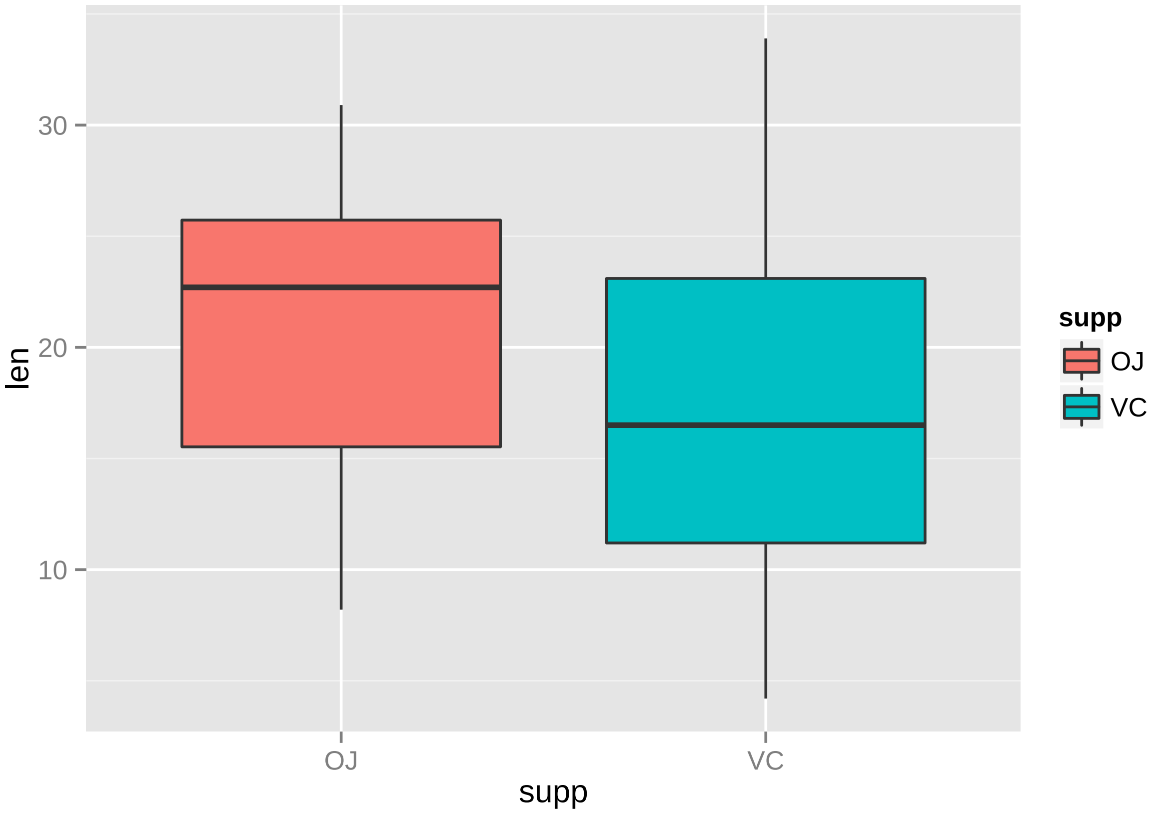
```
table(TG$dose,TG$supp)
```

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

We see that there are two supplements, either OJ or VC and three doses, .5, 1, and 2. We can also see that the tooth growth was between 4.2 and 33.9.

We can graph this data to see how it looks, first separating it by supplement:

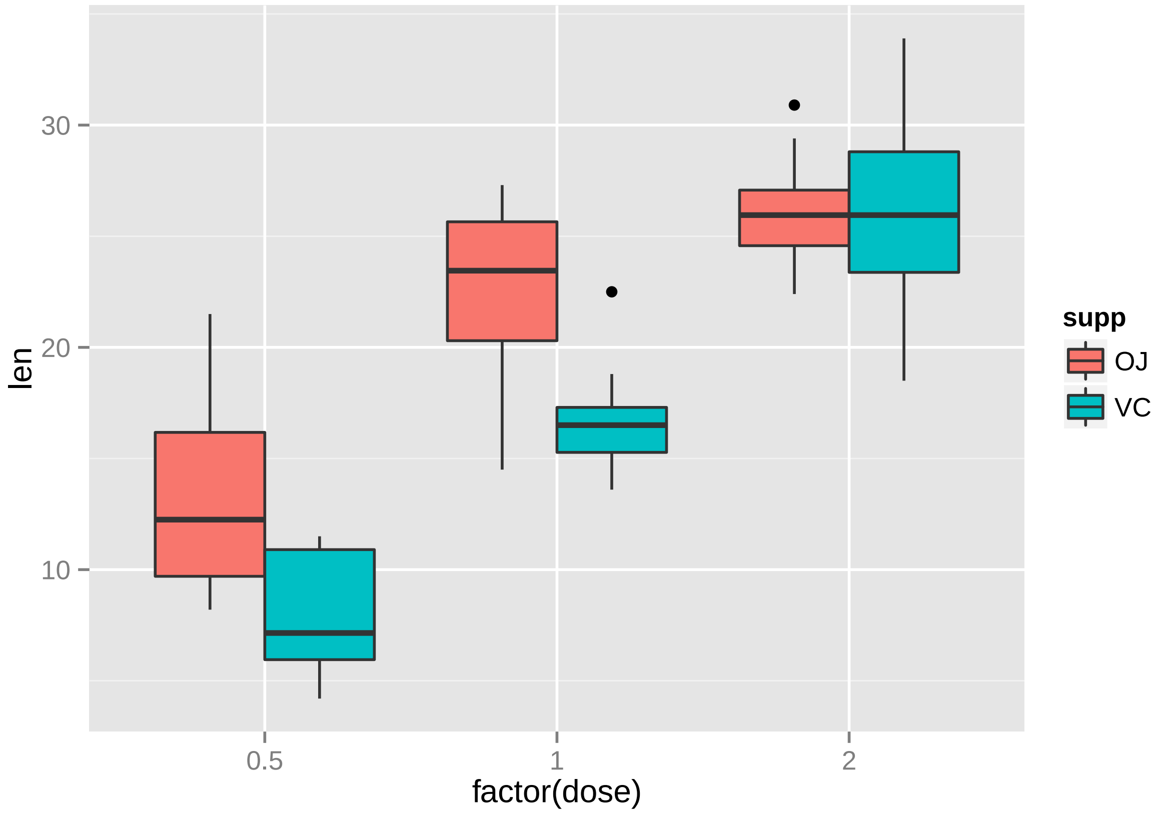
```
ggplot(TG)+ geom_boxplot(aes(y=len,x=supp, fill=supp))
```



It looks like orange juice results in longer teeth than vitamin C.

Now, we'll separate it by dose as well:

```
ggplot(aes(y=len,x=factor(dose), fill=supp), data=TG)+geom_boxplot()
```



From the graph, we see that higher doses seem to correspond to with more growth. Also, that at the lower doses, there was a tendency to more growth with orange juice than with plain vitamin C. However, at the highest dose (2.0) The means were almost the same, but there was wider variation with vitamin C than with orange juice.

Assumptions

We're also going to make some assumptions about the experiments and resulting data. First, we're assuming that the populations are independent and unpaired, but that the variances of the populations are the same. We're also going to assume that the study was done with by randomly assigning the guinea pigs to test groups and that the study was done in a double blind fashion. We also assume that there are no factors other than the supplement and dosage.

Data Analysis

Vitamin C vs. Orange Juice

We begin by looking at the difference between vitamin C & orange juice across all doses. A t-test should allow us to Our H_0 is that the means of the two different groups are the same.

```
VCTG <- (filter(TG, supp=="VC"))$len
OJTG <- (filter(TG, supp=="OJ"))$len
t.test(OJTG, VCTG, paired=FALSE, var.equal=TRUE, data=TG)
```

```
##
##  Two Sample t-test
##
## data:  OJTG and VCTG
## t = 1.915, df = 58, p-value = 0.06039
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.167  7.567
## sample estimates:
## mean of x mean of y
##     20.66     16.96
```

As we can see, our p-value is greater than $/alpha$ and our test statistic is 1.9153, but the confidence interval contains 0. With those values, we cannot reject the null hypothesis. This leads us to our next examination

Orange Juice v. Vitamin C by dose

We now want to see if there may be a difference at the various dosage levels - in other words, does a .5 mg dose of orange juice have a different mean than a .5 dose of vitamin C, etc. In these cases, our H_0 is that the means of the tooth growth of the orange juice group and the vitamin C group are the same. First, we'll create the subsets to make it easier to compare the groups.

```
OJHalf <- filter(TG, supp=="OJ",dose==.5)$len
VCHalf <- filter(TG, supp=="VC",dose==.5)$len
OJOne <- filter(TG, supp=="OJ",dose==1)$len
VCOne <- filter(TG, supp=="VC",dose==1)$len
OJTwo <- filter(TG, supp=="OJ",dose==2)$len
VCTwo <- filter(TG, supp=="VC",dose==2)$len
```

We then run t-tests for the various groups.

```
compareHalf <- t.test(OJHalf, VCHalf, paired=FALSE, var.equal=TRUE)
compareOne <- t.test(OJOne, VCOne, paired=FALSE, var.equal=TRUE)
compareTwo <- t.test(OJTwo,VCTwo, paired=FALSE, var.equal=TRUE)
compareSuppbyDose <- data.frame(rbind(compareHalf,compareOne,compareTwo)) %>% select(statistic,p.value,
compareSuppbyDose
```

```
##             statistic   p.value      conf.int
## compareHalf      3.17  0.005304    1.77, 8.73
## compareOne      4.033 0.0007807  2.841, 9.019
## compareTwo   -0.04614    0.9637 -3.723, 3.563
```

For .5mg, we have a p-value of .005, a t-statistic of 3.17, and the confidence interval doesn't contain 0. We can reject the null hypothesis and conclude that the means are different. For 1mg, the p-value is again tiny, .0008 and a t-statistic of 4.03. The confidence interval doesn't contain 0, so we can again reject the null hypothesis. But for the dosage of 2mg, our p-value is .964, the confidence interval straddles 0, the test statistic is -.046. Based on this, for a dosage of 2mg, we can't reject the null.

Dose v. Dose within the various groups

The final thing we want to confirm is the rough observation of whether increasing the dose makes a change for each supplement. First the orange juice populations:

```r
OJ.5to1 <- t.test(OJHalf, OJOne, paired=FALSE, var.equal=TRUE)
OJ1to2 <- t.test(OJOne, OJTwo, paired=FALSE, var.equal=TRUE)
OJ.5to2 <- t.test(OJHalf, OJTwo, paired=FALSE, var.equal=TRUE)
ojCompare <- data.frame(rbind(OJ.5to1,OJ1to2,OJ.5to2)) %>% select(statistic,p.value,conf.int)
ojCompare
```

```
##         statistic   p.value         conf.int
## OJ.5to1    -5.049 8.358e-05  -13.411, -5.529
## OJ1to2     -2.248   0.03736 -6.5005, -0.2195
## OJ.5to2    -7.817 3.402e-07  -16.278, -9.382
```

For all three of these, we have fairly small p-values (two are less than .0001, the third is still under .04), the confidence intervals do not contain 0, and the t-statistics are low. For all of these, we can reject the null hypothesis and conclude that the means are different and that changing the dosage does have an effect with the Orange Juice supplement.

We do similar tests with the vitamin C populations

```r
VC.5to1 <- t.test(VCHalf, VCOne, paired=FALSE, var.equal=TRUE)
VC1to2 <- t.test(VCOne, VCTwo, paired=FALSE, var.equal=TRUE)
VC.5to2 <- t.test(VCHalf, VCTwo, paired=FALSE, var.equal=TRUE)
vcCompare <- data.frame(rbind(VC.5to1,VC1to2,VC.5to2)) %>% select(statistic,p.value,conf.int)
vcCompare
```

```
##         statistic   p.value        conf.int
## VC.5to1    -7.463 6.492e-07 -11.264, -6.316
## VC1to2      -5.47 3.398e-05 -12.969, -5.771
## VC.5to2    -10.39 4.957e-09  -21.83, -14.49
```

All three of these p-values are ridiculously small and the confidence intervals and t-statistics all point to rejecting the null hypothesis. For the vitamin C supplement, there is an effect when the dosage is changed.

Conclusion

Based on our test results, we can come to the following conclusions. Generally speaking high doses of a particular supplement lead to more tooth growth than low doses of the same supplement. We can also conclude that at low doses, vitamin C is not as effective as orange juice for promoting tooth growth in guinea pigs, but at high doses both supplements are of similar efficacy.