Statistical Inference Project Report

Part 2 - Statistical Analysis and Hypothesis Testing

Introduction

This is a report submitted to fulfill the requirements of the Statistical Inference course offered by Johns Hopkins University on Coursera. It covers the basics of statistical anlysis and hypothesis testing.

Statistal Analysis and Hypothesis Testing

For this exercise, the "ToothGrowth" dataset from the "datasets" library will be used. This dataset contains information regarding the growth of the teeth of guinea pigs when they were given a vitamin C supplement. Two different supplement types were administered - namely, orange juice and ascorbic acid - and three different dosage amounts were used - that is, 0.5 mg/day, 1.0 mg/day and 2.0 mg/day.

Initial Exploratory Analysis

A basic initial analysis will give some indication as to the information contained in the dataset, and boxplots willgive an idea on what that information indicates. The R-code for the initial analysis is given below, and the results are as shown.

```
# load the necessary libraries
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 3.5.1
```

```
library(datasets)

# show the first few lines of the dataset
head(ToothGrowth)
```

```
##    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
## 5  6.4   VC  0.5
## 6 10.0   VC  0.5
```

```
# identify the unique levels of the dose variable
unique(ToothGrowth$dose)
```

```
## [1] 0.5 1.0 2.0
```

```
#identify the unique levels of the supplement variable
unique(ToothGrowth$supp)
```

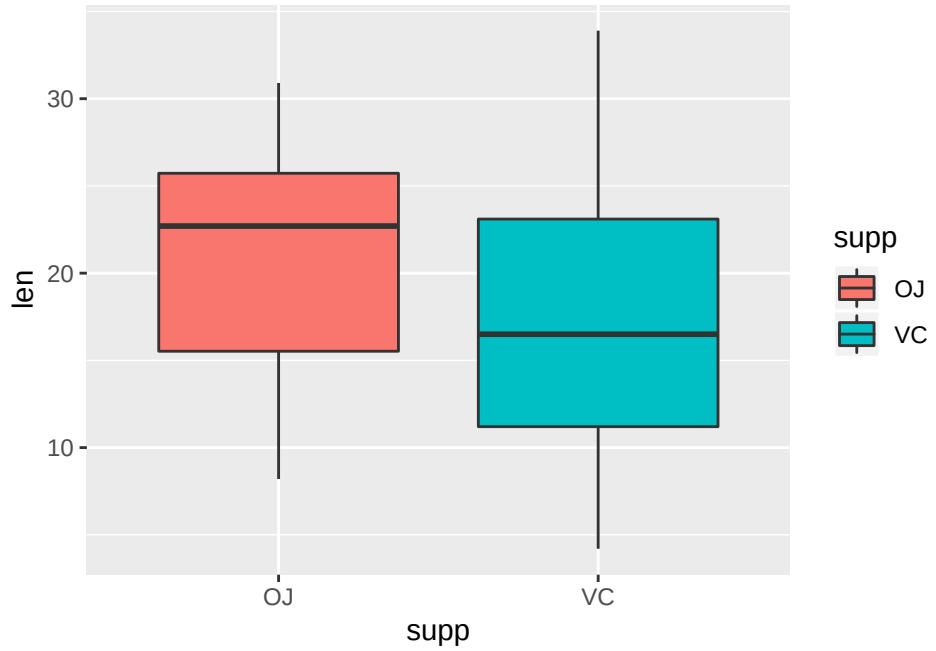
```
## [1] VC OJ
## Levels: OJ VC
```

```
# show a short summary of the data
summary(ToothGrowth)
```

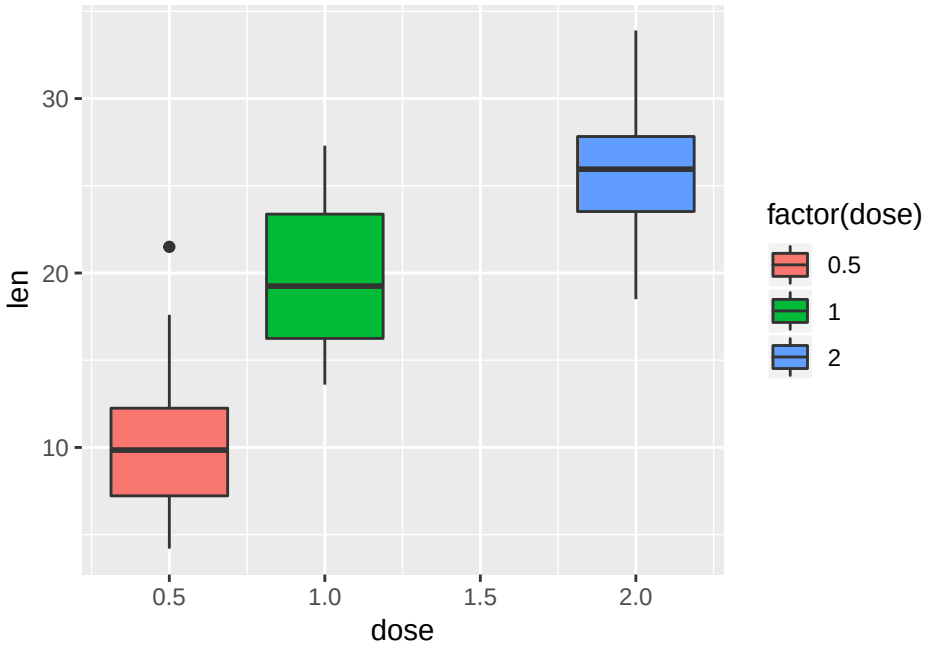
```
##       len        supp         dose
##  Min.   : 4.20   OJ:30   Min.   :0.500
##  1st Qu.:13.07   VC:30   1st Qu.:0.500
```

```
##  Median :19.25           Median :1.000
##  Mean   :18.81           Mean   :1.167
##  3rd Qu.:25.27           3rd Qu.:2.000
##  Max.   :33.90           Max.   :2.000
```

```r
# draw a boxplot showing the change in tooth length due to the different supplement types
tooth_plot_01 <- ggplot(data = ToothGrowth, aes(x = supp, y = len)) +
                 geom_boxplot(aes(fill = supp))
print(tooth_plot_01)
```




```r
# draw a boxplot showing the change in tooth length due to the different dosages
tooth_plot_02 <- ggplot(data = ToothGrowth, aes(x = dose, y = len)) +
                 geom_boxplot(aes(fill = factor(dose)))
print(tooth_plot_02)
```



The first plot show that there does appear to be a link between increased tooth growth and the supplement type, while the second plot shows that there does appear to be a link between increased tooth growth and an increased vitamin C dose. However, these observations can only be confirmed or denied with a statistical anlysis of the data, which is what will now be done.

Hypothesis Testing - Assumptions

Very little informatin is available regarding this dataset. However the following assumptions are made and kept in mind regarding the analysis which is to follow: 1. The data are assummed to be independent. 2. The data are assumed to be un-paired. 3. Unequal variances are assumed for the data, which means that the Student's t-test will be used for the analysis.

Hypothesis Number 1 - Tooth Growth as a Function of Supplement Type

The first analysis will investigate the change in tooth length as a function of the supplement type administered. In other words, this aims to identify whether one of the supplement types has a greater effect than the other. The hypotheses to be tested are listed below: H_0: the change is the same for both supplement types administered (the null hypothesis) H_a: the change is different for each supplement type (the alternative hypothesis)

The t-test for this is run using the R-code below and the results are as shown:

```
test01 <- t.test(len ~ supp, data = ToothGrowth, paired = FALSE)
```

The results yield a p-value of 0.06. This is just above the rejection value of 0.05. The 95% confidence interval also contains the value of 0. This means that it is possible that there is zero difference in the mean values due to each of the supplement types. Based on this information, we cannot reject the null hypothesis and resolve to accept it, stating that the change in tooth length is the same for both supplement types administered.

Hypothesis Number 2 - Tooth Growth as a Fuction of Dosage

The second analysis will investigate the change in tooth length as a function of the dosage size administered. In other words, this aims to identify whether a larger dose has a greater effect on the growth of the teeth than does a smaller dose. The hypootheses to be tested are listed below: H_0: the shange in length is the

same for all doses (the null hypothesis) H_a: the change in length is different for each dose (the alternative hypothesis)

First, the data must be subset into three groups, each containing the information relating to two dosage levels. The t-test is then performed on each of the three subsets. The R-code for this is given below and the results are as shown:

```
growth_dose_A <- subset(ToothGrowth, dose %in% c(0.5, 1.0))
t.test(len ~ dose, data = growth_dose_A, paired = FALSE)
```

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -6.4766, df = 37.986, p-value = 1.268e-07
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -11.983781  -6.276219
## sample estimates:
## mean in group 0.5   mean in group 1
##            10.605            19.735
```

```
growth_dose_B <- subset(ToothGrowth, dose %in% c(1.0, 2.0))
t.test(len ~ dose, data = growth_dose_B, paired = FALSE)
```

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -4.9005, df = 37.101, p-value = 1.906e-05
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -8.996481 -3.733519
## sample estimates:
## mean in group 1 mean in group 2
##          19.735          26.100
```

```
growth_dose_C <- subset(ToothGrowth, dose %in% c(0.5, 2.0))
t.test(len ~ dose, data = growth_dose_C, paired = FALSE)
```

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -11.799, df = 36.883, p-value = 4.398e-14
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -18.15617 -12.83383
## sample estimates:
## mean in group 0.5   mean in group 2
##            10.605            26.100
```

As can be seen from the results, all three p-values are very close to 0, which is well below the 0.05 rejection limit. Also, none of the 95% confidence intervals contain zero, which implies that the difference is the means cannot be zero so the mean values cannot be the same. Therefore we conclude that the dosage of vitamin C does in fact have an effect on the growth of the teeth, with a greater dose resulting in increased tooth growth, and this leads us to reject the null hypothesis in favour of the alternative.