Statistical Inference : Course Project

Basic Inferential Data Analysis:

Analysis of ToothGrowth Data:

Load ToothGrowth Data :

```
data(ToothGrowth)
```

Exploratory Data Analysis :

```
str(ToothGrowth) # Review Data Structure
```

```
## '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 2 ...
##  $ dose: num  0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 ...
```

```
summary(ToothGrowth) # Review Data Statistics
```

```
##       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
```

```
head(ToothGrowth) # Review some of the actual data
```

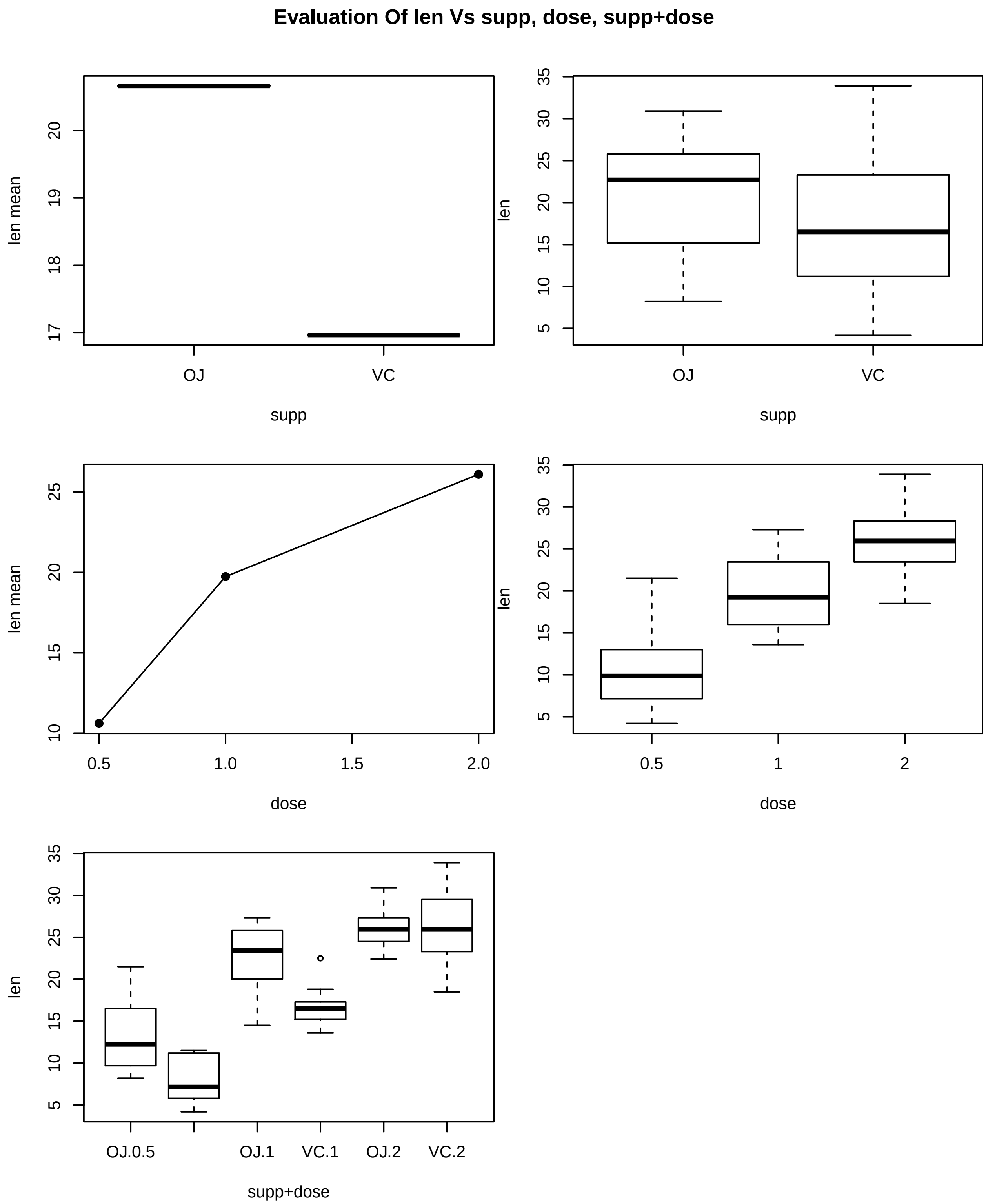
```
##    len supp dose
## 1  4.2   VC  0.5
## 2 11.5   VC  0.5
## 3  7.3   VC  0.5
## 4  5.8   VC  0.5
## 5  6.4   VC  0.5
## 6 10.0   VC  0.5
```

```
unique(ToothGrowth$dose) # Review unique values of dose control variable.
```

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

Plots to Evaluate relation of "len"" with "supp" and "dose" :

```
par(mfrow=c(3,2),mar=c(4,4,2,0),oma=c(0,0,2,0))
plot(aggregate(len~supp,ToothGrowth,mean),ylab="len mean")
boxplot(len~supp,ToothGrowth,xlab="supp",ylab="len")
plot(aggregate(len~dose,ToothGrowth,mean),pch=19, ylab="len mean")
lines(aggregate(len~dose,ToothGrowth,mean))
boxplot(len~dose,ToothGrowth,xlab="dose",ylab="len")
boxplot(len~supp+dose,ToothGrowth,xlab="supp+dose",ylab="len")
title(main="Evaluation Of len Vs supp, dose, supp+dose",outer=T)
```



"ToothGrowth" data structure and summary overview shows that the data set has **60** observations of **3** variables, **"len"**, **"supp"** and **"dose"**. **"len"** and **"dose"** are **numeric**, while **"supp"** is a factor variable. Summary statistics show that variable **"len"** has a max value **- 33.9**, min value **- 4.2** and mean **- 18.8133**. Variable **"supp"** has only **two** unique values with **30 observations** each. Variable dose has a max value **- 2**, min value **- 0.5** and mean **- 1.1667**. Further review of variable **"dose"** shows that it has only three unique values, **0.5,1 & 2**. If necessary, we can always convert **"dose"** to a factor variable.

Objective of this data analysis is to evaluate the impact of **control** variables **"supp"** and **"dose"** on the **target** variable **"len"**, individually or together. Assuming that a higher **"len"** value indicates a higher impact and a higher value of or **"dose"** indicates a higher dose, a first evaluation of the above plots, yields the following hypotheses :

1. For impact of control variable **"supp"** only on target variable **"len"**, **"OJ"** has a higher impact on target variable **"len"**.

2. For impact of control variable **"dose"** only on target variable **"len"**, higher the **"dose"**, higher is the impact.

3. For combined impact of control variables **"supp"** and **"dose"**, **"OJ"** has higher impact on target variable **"len"** for **"dose"** **0.5 & 1**.

4. For combined impact of control variables **"supp"** and **"dose"**, **"OJ"** and **"VC"** have same impact on target variable **"len"** for **"dose"** **2**.

Hypothesis Testing :

Hypothesis #1 - For impact of control variable **"supp"** only on target variable **"len"**, **"OJ"** has a higher impact on target variable **"len"** :

```
G=t.test(len~supp,paired=F,var.equal=F,data=ToothGrowth);print(G)
```

```
##
##  Welch Two Sample t-test
##
## data:  len by supp
## t = 1.915, df = 55.31, p-value = 0.06063
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.171  7.571
## sample estimates:
## mean in group OJ mean in group VC
##            20.66            16.96
```

P-Value, 0.0606 is greater than α=0.05 (α for confidence interval of 95%), confidence interval, (-0.171, 7.571) for the difference of the means of each group spans 0, hence **null hypothesis** is **Failed to Reject**, hence Hypothesis #1 is **Rejected**.

Hypothesis #2 - For impact of control variable **"dose"** only on target variable **"len"**, Higher the **"dose"**, higher is the impact :

2a : ***dose 1 has higher impact than dose 0.5***

```r
Ga=t.test(len~dose,paired=F,var.equal=F,data=ToothGrowth[ToothGrowth$dose%in%c(0.5,1),]);print(Ga)
```

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -6.477, df = 37.99, p-value = 1.268e-07
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -11.984  -6.276
## sample estimates:
## mean in group 0.5   mean in group 1
##             10.61             19.73
```

P-Value, 1.2683 × 10-7 is less than α=0.05 (α for confidence interval of 95%), confidence interval, (-11.9838, -6.2762) for the difference of the means of each group doesnot span 0, hence **null hypothesis** is **Rejected**, hence Hypothesis #2a is **Failed to Reject**.

2b : ***dose 2 has higher impact than dose 1***

```r
Gb=t.test(len~dose,paired=F,var.equal=F,data=ToothGrowth[ToothGrowth$dose%in%c(1,2),]);print(Gb)
```

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -4.901, df = 37.1, p-value = 1.906e-05
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -8.996 -3.734
## sample estimates:
## mean in group 1 mean in group 2
##           19.73           26.10
```

P-Value, 1.9064 × 10-5 is less than α=0.05 (α for confidence interval of 95%), confidence interval, (-8.9965, -3.7335) for the difference of the means of each group doesnot span 0, hence **null hypothesis** is **Rejected**, hence Hypothesis #2b is **Failed to Reject**.

Hypothesis 2 is **Failed to Reject** , based on above two evaluations.

Hypothesis #3 - For combined impact of control variable **"supp"** and **"dose"**, **"OJ"** has higher impact on target variable **"len"** for **"dose"** 0.5 & 1 :

3a : ***"OJ" has higher impact for dose 0.5***

```r
Ga=t.test(len~supp,paired=F,var.equal=F,data=ToothGrowth[ToothGrowth$dose==0.5,]);print(Ga)
```

```
##
##  Welch Two Sample t-test
##
```

```
## data:  len by supp
## t = 3.17, df = 14.97, p-value = 0.006359
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  1.719 8.781
## sample estimates:
## mean in group OJ mean in group VC
##            13.23             7.98
```

P-Value, 0.0064 is less than α=0.05 (α for confidence interval of 95%), confidence interval, (1.7191, 8.7809) for the difference of the means of each group doesnot span 0, hence **null hypothesis** is **Rejected**, hence Hypothesis #3a is **Failed to Reject**.

3b : *"OJ" has higher impact for dose 1*

```
Gb=t.test(len~supp,paired=F,var.equal=F,data=ToothGrowth[ToothGrowth$dose==1,]);print(Gb)
```

```
##
##  Welch Two Sample t-test
##
## data:  len by supp
## t = 4.033, df = 15.36, p-value = 0.001038
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  2.802 9.058
## sample estimates:
## mean in group OJ mean in group VC
##            22.70            16.77
```

P-Value, 0.001 is less than α=0.05 (α for confidence interval of 95%), confidence interval, (2.8021, 9.0579) for the difference of the means of each group doesnot span 0, hence **null hypothesis** is **Rejected**, hence Hypothesis #3b is **Failed to Reject**.

Hypothesis 3 is **Failed to Reject** , based on above two evaluations.

Hypothesis #4 - For combined impact of control variables **"supp"** and **"dose"**, **"OJ"** and **"VC"** have same impact on target varibale **"len"** for **"dose"** 2 :

```
G=t.test(len~supp,paired=F,var.equal=F,data=ToothGrowth[ToothGrowth$dose==2,]);print(G)
```

```
##
##  Welch Two Sample t-test
##
## data:  len by supp
## t = -0.0461, df = 14.04, p-value = 0.9639
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -3.798  3.638
## sample estimates:
## mean in group OJ mean in group VC
##            26.06            26.14
```

P-Value, 0.9639 is greater than α=0.05 (α for confidence interval of 95%), confidence interval, (-3.7981, 3.6381) for the difference of the means of each group spans 0, hence **null hypothesis** is **Failed to Reject**, hence Hypothesis #4 is **Failed to Reject**.

Conclusions & Assumptions :

Conclusions: Based on the above evaluation of the four hypothesis, following are the conclusions:

1. For impact of control variable **"supp"** only, there is no significant difference on target variable **"len"** for different values of **"supp"**.
2. For impact of control variable **"dose"** only, higher the dose, higher is the impact on target variable **"len"**.
3. For combined impact of control variables, there is significant difference on target variable "len" for different values of **"supp"** for **"dose 0.5 and 1"**. There is no significant difference for different values of **"supp"** for **"dose 2"**.

Assumptions:

1. A higher value of **"len"** indicates a higher impact.
2. Higher value of **"dose"** indicates increased dosages.
3. Data provided is independently distributed.
4. Data follows T distribution as the observations are limited.
5. Data is derived from samples representative of the population.
6. Variances are considered to be unequal.