Assignment-6.R

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```
library(Sleuth3)
```

```
## Warning: package 'Sleuth3' was built under R version 3.4.2
```

```
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 3.4.2
```

```
library(agricolae)
```

```
## Warning: package 'agricolae' was built under R version 3.4.2
```

```
library(multcomp)
```

```
## Loading required package: mvtnorm
```

```
## Warning: package 'mvtnorm' was built under R version 3.4.1
```

```
## Loading required package: survival
```

```
## Loading required package: TH.data
```

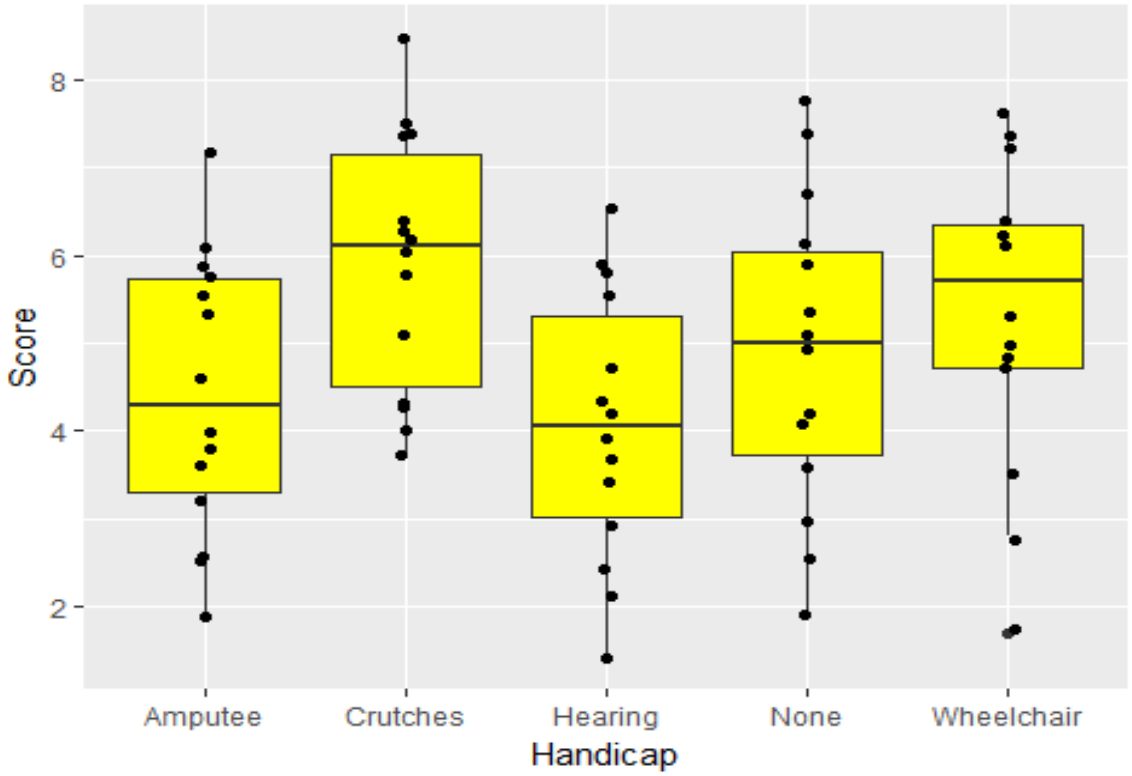
```
## Warning: package 'TH.data' was built under R version 3.4.2
```

```
## Loading required package: MASS
```

```
##
## Attaching package: 'TH.data'
```

```
## The following object is masked from 'package:MASS':
##
##     geyser
```

```
ggplot(data = case0601, aes(Handicap, Score)) + geom_boxplot(fill = "yellow")
+
  geom_jitter(width = 0.03)
```




```
##Q1

Handicap_Mod <- aov(Score ~ Handicap, data = case0601)

##Tukey-test
Handicap_Tukey <- glht(Handicap_Mod, linfct = mcp(Handicap = "Tukey"))
confint(Handicap_Tukey)

##
##   Simultaneous Confidence Intervals
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: aov(formula = Score ~ Handicap, data = case0601)
##
## Quantile = 2.8065
## 95% family-wise confidence level
##
##
## Linear Hypotheses:
##                             Estimate lwr     upr
## Crutches - Amputee == 0      1.4929  -0.2393  3.2250
## Hearing - Amputee == 0      -0.3786  -2.1107  1.3536
## None - Amputee == 0          0.4714  -1.2607  2.2036
## Wheelchair - Amputee == 0    0.9143  -0.8179  2.6464
```

```
## Hearing - Crutches == 0    -1.8714  -3.6036 -0.1393
## None - Crutches == 0       -1.0214  -2.7536  0.7107
## Wheelchair - Crutches == 0 -0.5786  -2.3107  1.1536
## None - Hearing == 0         0.8500  -0.8822  2.5822
## Wheelchair - Hearing == 0   1.2929  -0.4393  3.0250
## Wheelchair - None == 0      0.4429  -1.2893  2.1750

Sum of the CI difference (sum of the estimate) = 1.6144

Average of the estimate = 0.16144



HSD.test(Handicap_Mod, "Handicap", group = FALSE, alpha = 0.05, console = TRU
E)

##
## Study: Handicap_Mod ~ "Handicap"
##
## HSD Test for Score
##
## Mean Square Error:  2.666484
##
## Handicap,  means
##
##               Score      std  r Min Max
## Amputee    4.428571 1.585719 14 1.9 7.2
## Crutches   5.921429 1.481776 14 3.7 8.5
## Hearing    4.050000 1.532595 14 1.4 6.5
## None       4.900000 1.793578 14 1.9 7.8
## Wheelchair 5.342857 1.748280 14 1.7 7.6
##
## Alpha: 0.05 ; DF Error: 65
## Critical Value of Studentized Range: 3.968034
##
## Comparison between treatments means
##
##                       difference pvalue signif.        LCL       UCL
## Amputee - Crutches    -1.4928571 0.1233         -3.2245899 0.2388756
## Amputee - Hearing      0.3785714 0.9725         -1.3531613 2.1103042
## Amputee - None        -0.4714286 0.9400         -2.2031613 1.2603042
## Amputee - Wheelchair  -0.9142857 0.5781         -2.6460185 0.8174470
## Crutches - Hearing     1.8714286 0.0278       *  0.1396958 3.6031613
## Crutches - None        1.0214286 0.4686         -0.7103042 2.7531613
## Crutches - Wheelchair  0.5785714 0.8812         -1.1531613 2.3103042
## Hearing - None        -0.8500000 0.6443         -2.5817328 0.8817328
## Hearing - Wheelchair  -1.2928571 0.2348         -3.0245899 0.4388756
## None - Wheelchair     -0.4428571 0.9517         -2.1745899 1.2888756

##Bonferroni
confint(Handicap_Tukey, calpha = univariate_calpha(), level = 0.995)
```

```
##
##   Simultaneous Confidence Intervals
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: aov(formula = Score ~ Handicap, data = case0601)
##
## Quantile = 2.906
## 99.5% confidence level
##
##
## Linear Hypotheses:
##                              Estimate lwr      upr
## Crutches - Amputee == 0       1.49286 -0.30071  3.28643
## Hearing - Amputee == 0       -0.37857 -2.17214  1.41500
## None - Amputee == 0           0.47143 -1.32214  2.26500
## Wheelchair - Amputee == 0     0.91429 -0.87928  2.70786
## Hearing - Crutches == 0      -1.87143 -3.66500 -0.07786
## None - Crutches == 0         -1.02143 -2.81500  0.77214
## Wheelchair - Crutches == 0   -0.57857 -2.37214  1.21500
## None - Hearing == 0           0.85000 -0.94357  2.64357
## Wheelchair - Hearing == 0     1.29286 -0.50071  3.08643
## Wheelchair - None == 0        0.44286 -1.35071  2.23643

Sum of the CI difference (sum of the estimate) = 1.61417

Average of the estimate = 0.161417



##Scheffe test
scheffe.test(Handicap_Mod, "Handicap", group = FALSE, alpha = 0.05, main = NU
LL, console = TRUE)

##
## Study: Handicap_Mod ~ "Handicap"
##
## Scheffe Test for Score
##
## Mean Square Error  : 2.666484
##
## Handicap,  means
##
##                Score      std  r Min Max
## Amputee     4.428571 1.585719 14 1.9 7.2
## Crutches    5.921429 1.481776 14 3.7 8.5
## Hearing     4.050000 1.532595 14 1.4 6.5
## None        4.900000 1.793578 14 1.9 7.8
## Wheelchair 5.342857 1.748280 14 1.7 7.6
##
```

```
## Alpha: 0.05 ; DF Error: 65
## Critical Value of F: 2.51304
##
## Comparison between treatments means
##
##                        Difference pvalue sig        LCL       UCL
## Amputee - Crutches    -1.4928571 0.2238     -3.6907943 0.7050801
## Amputee - Hearing      0.3785714 0.9840     -1.8193658 2.5765086
## Amputee - None        -0.4714286 0.9642     -2.6693658 1.7265086
## Amputee - Wheelchair  -0.9142857 0.7007     -3.1122229 1.2836515
## Crutches - Hearing     1.8714286 0.0682   . -0.3265086 4.0693658
## Crutches - None        1.0214286 0.6051     -1.1765086 3.2193658
## Crutches - Wheelchair  0.5785714 0.9265     -1.6193658 2.7765086
## Hearing - None        -0.8500000 0.7545     -3.0479372 1.3479372
## Hearing - Wheelchair  -1.2928571 0.3656     -3.4907943 0.9050801
## None - Wheelchair     -0.4428571 0.9715     -2.6407943 1.7550801

Sum of the CI difference (sum of the estimate) = 1.6142856

Average of the estimate = 0.16142856



##Fisher LSD
confint(Handicap_Tukey, calpha = univariate_calpha())

##
##   Simultaneous Confidence Intervals
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: aov(formula = Score ~ Handicap, data = case0601)
##
## Quantile = 1.9971
## 95% confidence level
##
##
## Linear Hypotheses:
##                             Estimate lwr      upr
## Crutches - Amputee == 0      1.49286  0.26024  2.72548
## Hearing - Amputee == 0      -0.37857 -1.61119  0.85405
## None - Amputee == 0          0.47143 -0.76119  1.70405
## Wheelchair - Amputee == 0    0.91429 -0.31833  2.14690
## Hearing - Crutches == 0     -1.87143 -3.10405 -0.63881
## None - Crutches == 0        -1.02143 -2.25405  0.21119
## Wheelchair - Crutches == 0 -0.57857 -1.81119  0.65405
## None - Hearing == 0          0.85000 -0.38262  2.08262
## Wheelchair - Hearing == 0    1.29286  0.06024  2.52548
## Wheelchair - None == 0       0.44286 -0.78976  1.67548
```

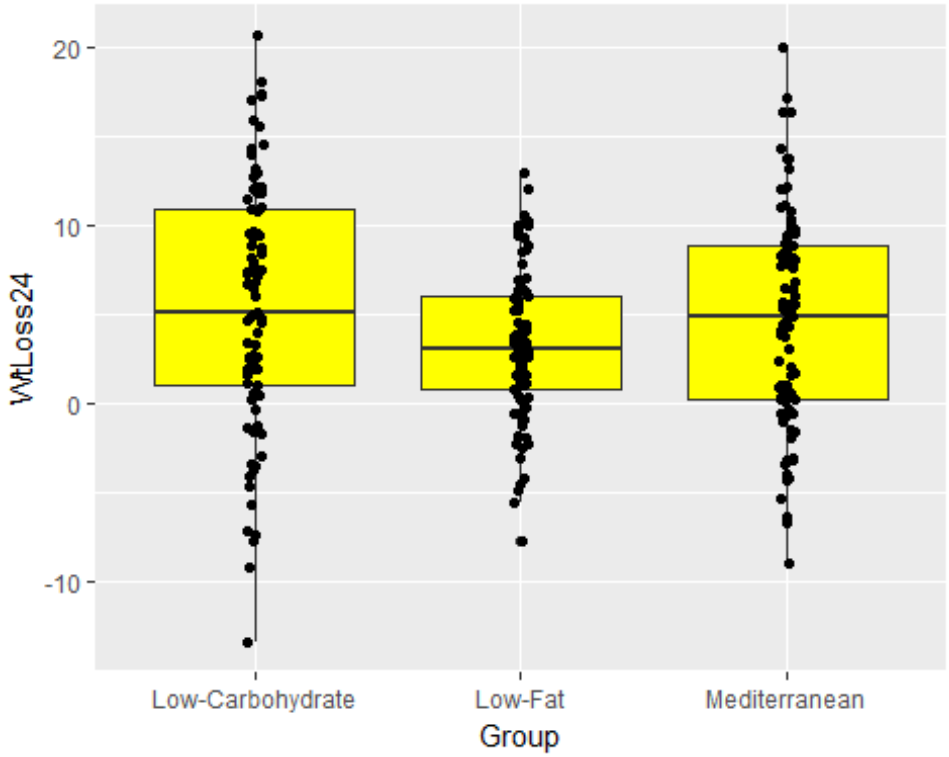
```
Sum of the CI difference (sum of the estimate) = 1.6143

Average of the estimate = 0.16143
```

```
LSD.test(Handicap_Mod, "Handicap", group = FALSE, alpha = 0.05, console = TRU
E)
```

```
##
## Study: Handicap_Mod ~ "Handicap"
##
## LSD t Test for Score
##
## Mean Square Error:  2.666484
##
## Handicap,  means and individual ( 95 %) CI
##
##               Score      std  r      LCL      UCL Min Max
## Amputee    4.428571 1.585719 14 3.556979 5.300164 1.9 7.2
## Crutches   5.921429 1.481776 14 5.049836 6.793021 3.7 8.5
## Hearing    4.050000 1.532595 14 3.178407 4.921593 1.4 6.5
## None       4.900000 1.793578 14 4.028407 5.771593 1.9 7.8
## Wheelchair 5.342857 1.748280 14 4.471265 6.214450 1.7 7.6
##
## Alpha: 0.05 ; DF Error: 65
## Critical Value of t: 1.997138
##
## Comparison between treatments means
##
##                       difference pvalue signif.        LCL        UCL
## Amputee - Crutches    -1.4928571 0.0184       * -2.7254751 -0.2602392
## Amputee - Hearing      0.3785714 0.5418         -0.8540465  1.6111894
## Amputee - None        -0.4714286 0.4477         -1.7040465  0.7611894
## Amputee - Wheelchair  -0.9142857 0.1433         -2.1469037  0.3183322
## Crutches - Hearing     1.8714286 0.0035      **  0.6388106  3.1040465
## Crutches - None        1.0214286 0.1028         -0.2111894  2.2540465
## Crutches - Wheelchair  0.5785714 0.3520         -0.6540465  1.8111894
## Hearing - None        -0.8500000 0.1732         -2.0826179  0.3826179
## Hearing - Wheelchair  -1.2928571 0.0401       * -2.5254751 -0.0602392
## None - Wheelchair     -0.4428571 0.4756         -1.6754751  0.7897608
```

As per the analysis of average of estimates, it could be observed that Tukey and LSD tend to provide lower decimal places estimate which means narrow CI intervals. LSD gives an average estimate of 0.16143 and Tukey gives 0.16144 which makes LSD better than Tukey. Thus, we can conclude that LSD is the most liberal procedure. On the other hand, Scheffe gives an average estimate of 0.16142856. Since, it gives a value of large decimal values, so it tends to have wide CI interval, making it a conservative procedure.

```
##Q2: Ex-6.23
ggplot(data = ex0623, aes(Group, WtLoss24)) + geom_boxplot(fill = "yellow") +
  geom_jitter(width = 0.03)
```




```
Wtloss_Mod <- aov(WtLoss24 ~ Group, data = ex0623)
summary(Wtloss_Mod)
```

```
##              Df Sum Sq Mean Sq F value Pr(>F)
## Group         2    217  108.43   3.236 0.0409 *
## Residuals   269   9014   33.51
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
wtloss_Tukey <- glht(Wtloss_Mod, linfct = mcp(Group = "Tukey"))
confint(wtloss_Tukey)
```

```
##
##   Simultaneous Confidence Intervals
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: aov(formula = WtLoss24 ~ Group, data = ex0623)
##
## Quantile = 2.3567
## 95% family-wise confidence level
##
```

```
##
## Linear Hypotheses:
##                                         Estimate lwr     upr
## Low-Fat - Low-Carbohydrate == 0         -2.1828  -4.2247 -0.1409
## Mediterranean - Low-Carbohydrate == 0 -0.8849  -2.9320  1.1622
## Mediterranean - Low-Fat == 0             1.2979  -0.6974  3.2932
```

```
HSD.test(Wtloss_Mod, "Group", group = FALSE, alpha = 0.05, console = TRUE)
```

```
##
## Study: Wtloss_Mod ~ "Group"
##
## HSD Test for WtLoss24
##
## Mean Square Error:  33.5089
##
## Group,  means
##
##                  WtLoss24      std  r   Min  Max
## Low-Carbohydrate 5.487059 7.004604 85 -13.4 20.7
## Low-Fat          3.304255 4.112554 94  -7.7 12.9
## Mediterranean    4.602151 6.006844 93  -9.0 20.0
##
## Alpha: 0.05 ; DF Error: 269
## Critical Value of Studentized Range: 3.332964
##
## Comparison between treatments means
##
##                                   difference pvalue signif.        LCL
## Low-Carbohydrate - Low-Fat         2.1828035 0.0329       *  0.1408361
## Low-Carbohydrate - Mediterranean  0.8849083 0.5657         -1.1622656
## Low-Fat - Mediterranean           -1.2978952 0.2771         -3.2932084
##                                        UCL
## Low-Carbohydrate - Low-Fat       4.224771
## Low-Carbohydrate - Mediterranean 2.932082
## Low-Fat - Mediterranean          0.697418
```

```
summary(wtloss_Tukey)
```

```
##
##   Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: aov(formula = WtLoss24 ~ Group, data = ex0623)
##
## Linear Hypotheses:
##                                         Estimate Std. Error t value Pr(>|t|)
## Low-Fat - Low-Carbohydrate == 0         -2.1828     0.8664  -2.519   0.0329
## Mediterranean - Low-Carbohydrate == 0  -0.8849     0.8686  -1.019   0.5656
```

```
## Mediterranean - Low-Fat == 0            1.2979     0.8466   1.533   0.2771
##
## Low-Fat - Low-Carbohydrate == 0       *
## Mediterranean - Low-Carbohydrate == 0
## Mediterranean - Low-Fat == 0
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

```
wtloss_dunnett <- glht(Wtloss_Mod, linfct = mcp(Group = "Dunnett"))
confint(wtloss_dunnett)
```

```
##
##   Simultaneous Confidence Intervals
##
## Multiple Comparisons of Means: Dunnett Contrasts
##
##
## Fit: aov(formula = WtLoss24 ~ Group, data = ex0623)
##
## Quantile = 2.221
## 95% family-wise confidence level
##
##
## Linear Hypotheses:
##                                      Estimate lwr     upr
## Low-Fat - Low-Carbohydrate == 0       -2.1828  -4.1071 -0.2585
## Mediterranean - Low-Carbohydrate == 0 -0.8849  -2.8142  1.0443
```

```
summary(wtloss_dunnett)
```

```
##
##   Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Dunnett Contrasts
##
##
## Fit: aov(formula = WtLoss24 ~ Group, data = ex0623)
##
## Linear Hypotheses:
##                                      Estimate Std. Error t value Pr(>|t|)
## Low-Fat - Low-Carbohydrate == 0       -2.1828     0.8664  -2.519   0.0232
## Mediterranean - Low-Carbohydrate == 0  -0.8849     0.8686  -1.019   0.4874
##
## Low-Fat - Low-Carbohydrate == 0       *
## Mediterranean - Low-Carbohydrate == 0
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

```
LSD.test(Wtloss_Mod, "Group", group = FALSE, alpha = 0.05, console = TRUE)
```

```
##
## Study: Wtloss_Mod ~ "Group"
##
## LSD t Test for WtLoss24
##
## Mean Square Error:  33.5089
##
## Group,  means and individual ( 95 %) CI
##
##                  WtLoss24      std  r      LCL      UCL   Min  Max
## Low-Carbohydrate 5.487059 7.004604 85 4.250892 6.723226 -13.4 20.7
## Low-Fat          3.304255 4.112554 94 2.128755 4.479755  -7.7 12.9
## Mediterranean    4.602151 6.006844 93 3.420348 5.783953  -9.0 20.0
##
## Alpha: 0.05 ; DF Error: 269
## Critical Value of t: 1.968822
##
## Comparison between treatments means
##
##                                   difference pvalue signif.        LCL
## Low-Carbohydrate - Low-Fat         2.1828035 0.0123       *  0.4769582
## Low-Carbohydrate - Mediterranean  0.8849083 0.3092         -0.8252865
## Low-Fat - Mediterranean           -1.2978952 0.1264         -2.9647660
##                                        UCL
## Low-Carbohydrate - Low-Fat       3.8886488
## Low-Carbohydrate - Mediterranean 2.5951031
## Low-Fat - Mediterranean          0.3689755
```

As it can be observed that Low Fat-Low Carbohydrate p-value is 0.012 which is less than 0.05 in each of these test, hence we can reject the null hypothesis and state that we have evidence to indicate the differences in average weight loss after two years for the given diets. LSD test can be used as a procedure to control for the family-wise confidence level.

The mean difference between `Low-Carbohydrate and Low-Fat is 2.1828035, Low-Carbohydrate and Mediterranean is 0.8849083 and Low-Fat and Mediterranean is -1.2978952. Additionally, it could be observed that CI difference in Low-Carbohydrate and Low-Fat is 3.4116906, Low-Carbohydrate and Mediterranean is 3.4203896 and Low-Fat and Mediterranean is 3.3337415.` Thus, we can conclude that Low Carbohydrate works better than other diets. Low fat diet did the worst among all in weight loss for 2 years.