

Problem 2

Here is the **code chunk** to do the calculation in Problem 2

1

```
heavysmoke_df <- read_csv(file = "./data/HeavySmoke.csv")
heavysmoke_df = janitor::clean_names(heavysmoke_df) %>%
  mutate(diff = bmi_6yrs-bmi_base) %>%
  mutate(mean = sum(diff)/length(bmi_6yrs)) %>%
  mutate(sd = (mean - diff)^2)

s_d_1= sqrt(sum((heavysmoke_df$sd))/(length(heavysmoke_df$id)-1))
t_statistics = 3.36 / (s_d_1/sqrt(9))
t_critical = qt(0.975,9)
t.test(heavysmoke_df$bmi_6yrs,heavysmoke_df$bmi_base,paired = T)
```

2

```
neversmoke_df <- read_csv(file = "./data/NeverSmoke.csv") %>%
  janitor::clean_names() %>%
  mutate(diff = bmi_6yrs-bmi_base) %>%
  mutate(mean = sum(diff)/length(bmi_6yrs)) %>%
  mutate(sd = (mean - diff)^2)

s_d_2 = sqrt(sum((neversmoke_df$sd))/(length(neversmoke_df$id)-1))
s_sqr = (9*s_d_1^2+9*s_d_2^2)/(18)
t_stat = (3.36 - 1.55) / (sqrt(s_sqr)*sqrt(1/9+1/9))
t_crit = qt(0.975,18)
diff_heavy = heavysmoke_df$bmi_6yrs - heavysmoke_df$bmi_base
diff_never = neversmoke_df$bmi_6yrs - neversmoke_df$bmi_base
f_crit=qt(0.975,9,9)
var.test(diff_heavy,diff_never,alternative = "two.sided")
res = t.test(diff_heavy,diff_never,var.equal = TRUE, paired = FALSE)
```

4

```
power.t.test(power = .90, delta = 3.0, sd=2.0, sig.level = 0.05, alternative = c("two.sided"))
power.t.test(power = .80, delta = 3.0, sd=2.0, sig.level = 0.05, alternative = c("two.sided"))
power.t.test(power = .90, delta = 3.0, sd=2.0, sig.level = 0.025, alternative = c("two.sided"))
power.t.test(power = .80, delta = 3.0, sd=2.0, sig.level = 0.025, alternative = c("two.sided"))
power.t.test(power = .90, delta = 1.7, sd=1.5, sig.level = 0.05, alternative = c("two.sided"))
power.t.test(power = .80, delta = 1.7, sd=1.5, sig.level = 0.05, alternative = c("two.sided"))
power.t.test(power = .90, delta = 1.7, sd=1.5, sig.level = 0.025, alternative = c("two.sided"))
power.t.test(power = .80, delta = 1.7, sd=1.5, sig.level = 0.025, alternative = c("two.sided"))
```

Problem 3

Here is the **code chunk** to read the files.

```
knee_df = read_csv(file = "./data/Knee.csv") %>%  
  janitor::clean_names()
```

1

Here is the **code chunk** to generate descriptive statistics for each group.

```
summary(knee_df$below)
```

```
##      Min. 1st Qu.  Median      Mean 3rd Qu.      Max.      NA's  
##       29       36       40       38      42      43         2
```

```
sd(knee_df $ below, na.rm = T)
```

```
## [1] 5.477226
```

```
summary(knee_df$average)
```

```
##      Min. 1st Qu.  Median      Mean 3rd Qu.      Max.  
##    28.00   30.25   32.00   33.00   35.00   39.00
```

```
sd(knee_df $average, na.rm = T)
```

```
## [1] 3.91578
```

```
summary(knee_df$above)
```

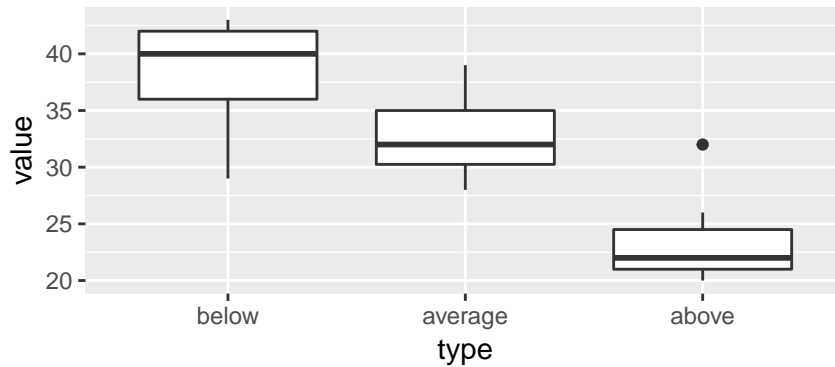
```
##      Min. 1st Qu.  Median      Mean 3rd Qu.      Max.      NA's  
##    20.00   21.00   22.00   23.57   24.50   32.00         3
```

```
sd(knee_df$above, na.rm = T)
```

```
## [1] 4.197505
```

From the vaue below, we could see the “below” group has the highest median and mean, while the “above” group has the slowest median and mean. The “below” group has the largest standard deviation 5.48 while the average has the lowest standard deviation 3.92. The box - plot of the given three groups of data is shown below:

```
knee_df = gather(knee_df, key = type, value = value, below:above) %>%  
  filter(!is.na(value))  
knee_df$type=as_factor(knee_df$type)  
ggplot(knee_df, aes(x = type, y = value)) + geom_boxplot()
```



2

Here is the **code chunk** to obtain the ANOVA table. The null hypothesis is all means of different groups are equal: $H_0: \mu_1 = \mu_2 = \mu_3$ The corresponding alternative hypothesis is that not all means are equal:

```
res <- aov(value~type,data = knee_df)
summary(res)
```

```
##           Df Sum Sq Mean Sq F value    Pr(>F)
## type         2   795.2    397.6   19.28 1.45e-05 ***
## Residuals    22   453.7     20.6
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

From the table, we are able to find that the p - value is $1.45e-05$, which is significantly lower than 0.05. We reject the null hypothesis and conclude that there is enough evidence to show that at least two of the means from the three groups “above”, “below” and “average” are different.

3

Now we performed pairwise comparisons with the appropriate adjustments (Bonferroni, Tukey, and Dunnett – ‘below average’ as reference). Here is the **code chunk**:

```
pairwise.t.test(knee_df$value,knee_df$type,p.adjust.method = 'bonferroni')
```

```
##
## Pairwise comparisons using t tests with pooled SD
##
## data:  knee_df$value and knee_df$type
##
##           below    average
## average 0.0898    -
## above   1.1e-05 0.0011
##
## P value adjustment method: bonferroni
```

The bonferroni test tends to compare samples with each other. From the data above, we can obtain the p-value from each comparison. The p-value of comparison between “average” and “below” is larger than 0.05, therefore we could not reject the null hypothesis and conclude that the mean of average and below groups is not different. Moreover, the p-value of comparison between “above” and “below” groups, and comparison between “average” and “above” groups, are less than 0.05, therefore we could reject the null hypothesis and

conclude that the mean of average and above group is different, and the mean of above and below group is also different.

```
TukeyHSD(res)
```

```
## Tukey multiple comparisons of means
## 95% family-wise confidence level
##
## Fit: aov(formula = value ~ type, data = knee_df)
##
## $type
##           diff          lwr          upr      p adj
## average-below -5.000000 -10.41130  0.4113011 0.0736833
## above-below   -14.428571 -20.33278 -8.5243579 0.0000102
## above-average  -9.428571 -15.05051 -3.8066356 0.0010053
```

The Tukey test also compare all possible pairs. From the data above, we find out that the means of “average - below” is same, while the means of “above - below” and “above - average” are different.

```
dunnetttest<-glht(res, linfct=mcp(type="Dunnett"))
summary(dunnetttest)
```

```
##
## Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Dunnett Contrasts
##
##
## Fit: aov(formula = value ~ type, data = knee_df)
##
## Linear Hypotheses:
##           Estimate Std. Error t value Pr(>|t|)
## average - below == 0   -5.000      2.154  -2.321  0.0543 .
## above - below == 0   -14.429      2.350  -6.139 6.93e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

The dunnett test compare all other samples with one sample, in our case, the “below” group. From the data above, we conclude that the means of “average - below” are the same while the “above - below” are different.

From the three tests above, we could see that Bonferroni and Tukey compared all possible pairs, while Dunnett need one pre - specified group to compare with all other samples. The bonferroni adjustment is the most conservative, since it adjusted to decrease α value, which makes it difficult to reject the null hypothesis and therefore decrease the power the test.

4

In conclusion, we perform the ANOVA test and following three adjustments (Benferroni, Tukey, and Dunnett) to analyze the relationship between physical status before therapy and the time (days) required in physical therapy until successful rehabilitation. The ANOVA indicates that at least the means of the two samples are different. The following adjustment indicates that it is the means of “above - below” and “above - average” are different.

Problem 4

Here is the **code chunk** to load the data file and conduct data cleaning:

```
library(datasets)
data("UCBAdmissions")

ucb_df <- as.data.frame(UCBAdmissions) %>%
  janitor::clean_names()
```

1

Here is the **code chunk** to provide point estimates and 95% CIs for the overall proportions of men and women admitted at Berkeley.

```
num_men_total = sum(filter(ucb_df,gender=="Male")$freq)
num_women_total = sum(filter(ucb_df,gender=="Female")$freq)
num_men_admitted = sum(filter(ucb_df,gender=="Male", admit=="Admitted")$freq)
num_women_admitted = sum(filter(ucb_df,gender=="Female", admit=="Admitted")$freq)

prop_men = num_men_admitted / num_men_total
prop_women = num_women_admitted / num_women_total

prop.test(num_men_admitted,num_men_total, p=0.5)
```

```
##
## 1-sample proportions test with continuity correction
##
## data:  num_men_admitted out of num_men_total, null probability 0.5
## X-squared = 32.12, df = 1, p-value = 1.449e-08
## alternative hypothesis: true p is not equal to 0.5
## 95 percent confidence interval:
##  0.4263168 0.4642163
## sample estimates:
##           p
## 0.4451877
```

```
prop.test(num_women_admitted,num_women_total,p=0.5)
```

```
##
## 1-sample proportions test with continuity correction
##
## data:  num_women_admitted out of num_women_total, null probability 0.5
## X-squared = 282.51, df = 1, p-value < 2.2e-16
## alternative hypothesis: true p is not equal to 0.5
## 95 percent confidence interval:
##  0.2826669 0.3252490
## sample estimates:
##           p
## 0.3035422
```

From the data above, we could obtain that the point estimate for the overall proportion of men admitted at Berkeley is 0.45, the 95% confidence interval (0.42, 0.46). The point estimate for the overall proportion of women admitted at Berkeley is 0.30, the 95% confidence interval is (0.28, 0.32). From the data above, we

observe that there is no overlap of the two confidence interval, and we could make a strong guess that indeed there exists sex bias in admission practices.

2

Here is **code chunk** to perform a hypothesis test to assess if the two proportions in previous example are significantly different. The null hypothesis H_0 is that $p_1=p_2$. The corresponding alternative hypothesis H_1 is that $p_1 \neq p_2$.

```
res <- prop.test(x = c(num_men_admitted, num_women_admitted), n = c(num_men_total, num_women_total))
res

##
## 2-sample test for equality of proportions with continuity
## correction
##
## data:  c(num_men_admitted, num_women_admitted) out of c(num_men_total, num_women_total)
## X-squared = 91.61, df = 1, p-value < 2.2e-16
## alternative hypothesis: two.sided
## 95 percent confidence interval:
##  0.1129887 0.1703022
## sample estimates:
##      prop 1      prop 2
## 0.4451877 0.3035422
```

From the data above, we could obtain the p-value is $2.2e-16$, which is way smaller than 0.05. We reject the null hypothesis and conclude that there is enough evidence to show that there is sex bias in admission practices.