Homework 2: Summary Statistics

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Due: November 20, 2019, 5:00 p.m

Hand Spans

WrHnd - the span of the student's writing hand (cm)
NWHnd - the span of the student's non-writing hand (cm)
(Span is the span of someone's hand is the distance from the tip of their thumb to the tip of their pinky finger when their hand is fully stretched.)

Design and Testing
As these measurements are the hands of the **same** subject, hypothesis testing will require the use of paired methods.
Potential methods include: Sign Test, Wilcoxon Signed Rank Test and the test method will be the paired *t*-test.

Hypothesis (based on the *a priori* assumption)
H$_0$: μ_W = μ_N On average, a student's writing hand and non-writing hand are equal.
H$_A$: μ_W > μ_N On average, a student's writing hand is larger than non-writing hand.

where;
μ_W : the population mean of the span of the student's writing hand.
μ_N : the population mean of the span of the student's non-writing hand.

Results Table

	Mean	StDev	DoF	T-Stat	p-value
WritingHand	18.6691	1.879			
NonWritingHand	18.5826	1.9671			
Difference	0.0864	0.6244			
Results			235	2.1268	0.0172

Two-sided Hypothesis on Differences

H$_0$: μ_W - μ_N = **0** On average Writing hand and non-writing hand are equal.
H$_A$: μ_W - μ_N $\neq$ **0** On average Writing hand is larger than non-writing hand.

```
    One Sample t-test

data:  diffHands
t = 2.1268, df = 235, p-value = 0.03448
alternative hypothesis: true mean is not equal to 0
95 percent confidence interval:
 0.006367389 0.166513967
sample estimates:
 mean of x
0.08644068
```

Interpreting the 95% CI

Given the sample, 95 out of 100 times the estimated mean of diffHands will fall between 0.0064, 0.1665 centimeters. The significance of this p-val < 0.05 means that the H_O would be Rejected and that the true mean of differences is not 0, based on this sample and this parametric test.

Assessing Normality

Q-Q Plot of Difference of Hand Spans
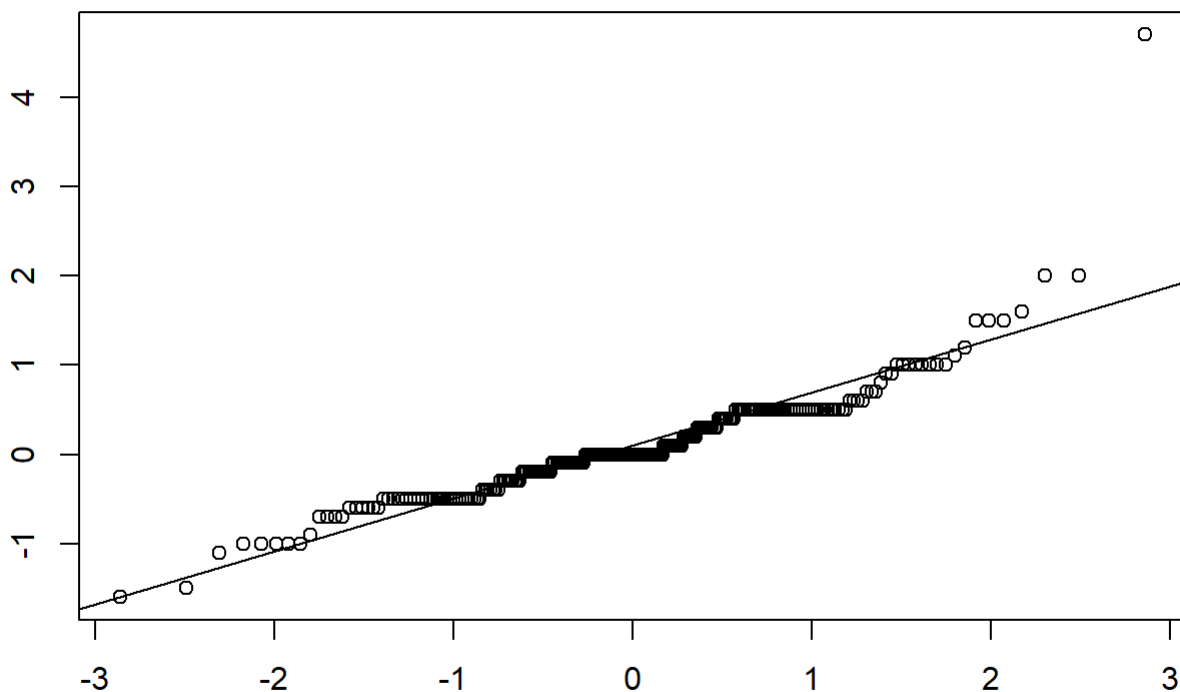
Based on the results of the qqplot, I would say that the population is not normal. The t-test should not be used. The "steps" that are plotted indicate high frequencies of the same values. Results of a Shapiro-Wilks normality test (seen below) indicate that this population does not approximate a normal distribution.

```
    Shapiro-Wilk normality test

data:  diffHands
W = 0.8757, p-value = 5.786e-13
```

Decision of the t-Test

The results of the two-sided t-test show: p-val=0.0345 < α=0.05

There is significant evidence to **_Reject H_0_**; The means span of Writing hand and non-Writing hand are not equal.

Nonparametric Sign Test

Assumption: This meant a two-sided test not on Differences and not a right-sided test of the a priori

```
library(DescTools)
signTest<-SignTest(W,N,mu=0,conf.level = 0.95,alternative = "two.sided")
signTest
```

```
    Dependent-samples Sign-Test

data:  W and N
S = 102, number of differences = 195, p-value = 0.5668
alternative hypothesis: true median difference is not equal to 0
95.7 percent confidence interval:
 0 0
sample estimates:
median of the differences
                        0
```

Decision of non-parametric Sign test:

Given the sample, roughly 96 out of 100 times the true mean of differences of Writing hand and Non-writing hand will be 0.

p-val=0.5668305 > α=0.05

Retain H_0

Conclusion

I chose to conduct a paired sample, because these variables are not independent of each other. They are measurements of the same subject.

Under the assumption of a normally distributed population, the t-test results in a rejection of the null hypothesis that the means of both samples are equal with a 95% confidence interval.

When not assuming a normally distributed population, the Sign test shows strong evidence that the null hypothesis should be retained; the means of writing hand and non-writing hand spans are approximately equal with a 95% confidence interval.

Based on my analysis of the normality of the data, and the results of the Shapiro-Wilks test, I have the most confidence in the Sign Test results that the population mean of the differences of Writing hand and non-writing hand are equal(approximately 0).

The steps in the QQ-plot push the data off a straight line and the outlier at the right tail concerned me. The Shapiro-Wilks test confirmed my suspicion that this was a non-parametric sample despite the abundance of samples. The non-parametric test is significant.

Based on these assumptions, I would agree with the SignTest and Retain H_0.

Age of Students

Age: Age (years) of the student.
MI: Whether the student reported their height in Metric or Imperial units of measure.

Design
These measures are unpaired. Ages and the system of measurement students use are *independant* of each other.

Testing
Welch *t*-test and Mann-Whitney

Welch's t-Test

Hypothesis
H_0: $\mu_A M = \mu_A I$ On average Age of those who reported in Metric and those who reported in Imperial are equal.
H_A: $\mu_A M \neq \mu_A I$ On average Age of those who reported in Metric and those who reported in Imperial are NOT equal.

where;
$\mu_A M$: population mean of the Age of those who reported in Metric.
$\mu_A I$: population mean of the Age of those who reported in Imperial.

Results Table

```
              Mean   StDev DoF T-Stat p-value
 AgeImperial 21.0736 8.5972
 AgeMetric   20.2885 5.5398
 Results                  95 0.6874  0.4935
```

Two-sided Hypothesis on Differences
Using the table function I found that there is an imbalance in the number of samples of Metric(n=141) and Imperial(n=68). In order to calculate the difference I took a sample of Metric users to match the number of records in Imperial users.

This was done using the sample(), without replacement, to take a random sample with a count of 68 of Metric to compare averages. A seed was set in order to easily replicate and reproduce the same numbers when run. I compared the mean of this Metric sample to the original mean and they are within .03 years of each other. Using this sample I calculated the differences and ran a the two-sided hypothesis test with 95% confidence level.

```
     One Sample t-test

data:  diffIM
t = 0.91564, df = 67, p-value = 0.3631
alternative hypothesis: true mean is not equal to 0
95 percent confidence interval:
 -1.220434  3.289140
sample estimates:
mean of x
 1.034353
```

Based on the results of the test on the differences in Age for Imperial/Metric users, the confidence interval reported is -1.2204, 3.2891 years.

This means that based on the sample 95 out of 100 times the population mean would fall between this range of age in years. This also means that the average age between the two populations in this sample is relatively low.
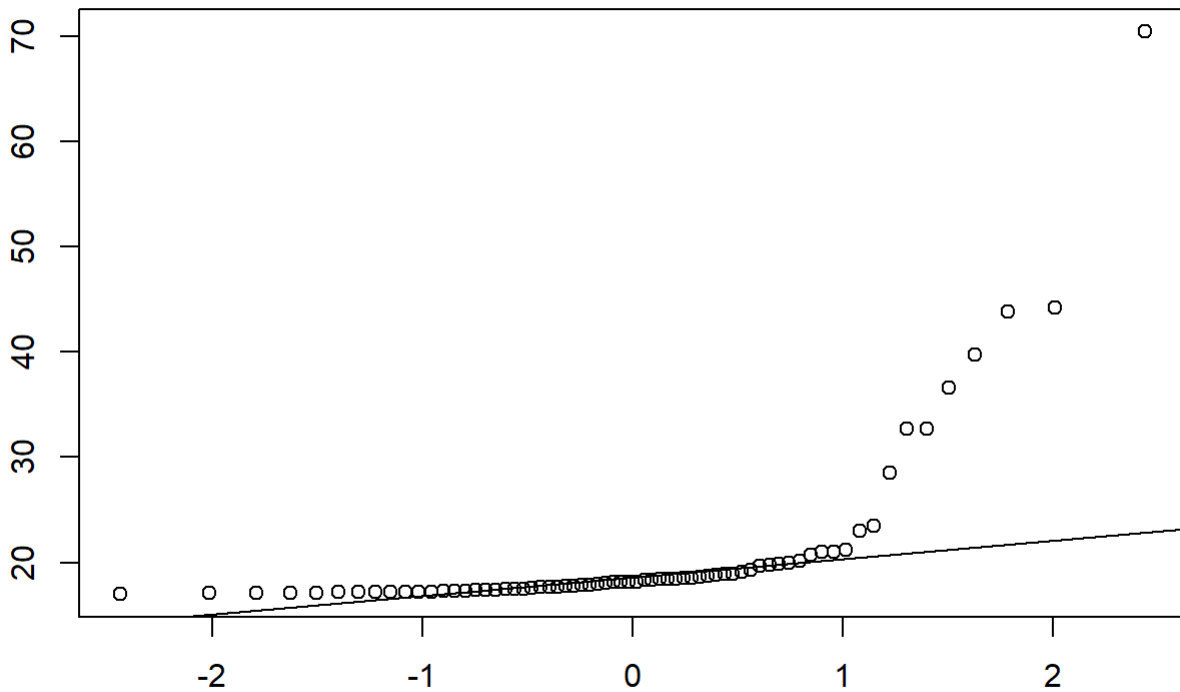
QQplots

Q-Q Plot of Age of Metric
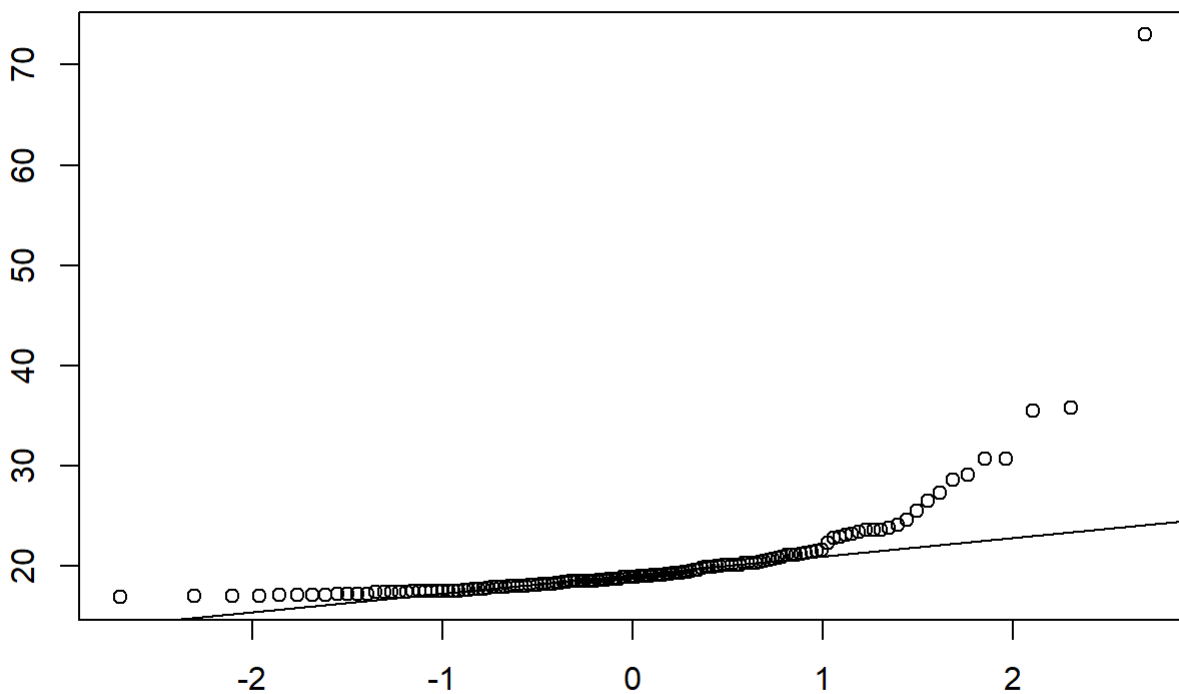
The QQ plot for the Age of Metric users is definitely NOT normal with a right skew.

Q-Q Plot of Age of Imperial

The QQ plot for the Age of Imperial users is definitely NOT normal with a right skew.

Decision of the Test

Based on the results of the unpaired t-test under parametric assumptions with 0.4935 is > α=0.05 there is evidence to Retain **H$_0$**: $\mu_A M = \mu_A I$ with 95% confidence.

Nonparametric Test

```
npIM<-wilcox.test(I,M,mu=0, alternative = "two.sided",conf.level=0.95)
npIM
```

```
    Wilcoxon rank sum test with continuity correction

data:  I and M
W = 3800, p-value = 0.01526
alternative hypothesis: true location shift is not equal to 0
```

Based on the results of the Mann-Whitney test:

p-val=0.0152618 < α=0.05

There is significant evidence to **Reject H$_0$**: The mean Age of Imperial users is not the same as the mean Age of Metric users.

Conclusions

Under parametric assumptions the Welch's t-test the p-val of 0.4935 is > α=0.05. Retain H$_0$:$\mu_A M = \mu_A I$. The p-val is > alpha, but the QQ plots of each show that both populations have issues assuming normality.

Under non-parametric assumptions the Mann-Whitney test shows: p-val= 0.0153 < α=0.05. These results are significant.

For this case, I have more trust in the non-parametric test and propose that the means of each population I and M are NOT equal and would **REJECT H_0**

Exercise Frequency

Sex: the gender of the student.
Exer: how often the student reported that they exercise.

Hypothesis
H_0: $\mu_P M = \mu_P F$ On average Male and Female student exercise frequency is the same.
H_A: $\mu_P M \neq \mu_P F$ On average Male and Female student exercise frequency is NOT the same.

where;
$\mu_P M$: population mean of the proportion of Males who exercise.
$\mu_P F$: population mean of the proportion of Females who exercise.

Distributions of Frequent Exercise in Females and Males

```
    Males Females
 x    65      49
 n   118     118
```

Sample Proportions for Female and Male Frequent Exercisers

```
          Estimate     X2 p-value
 Males     0.5702
 Females     0.5
 Results             1.2491  0.2637
```

Decision and Conclusion
Based on the results of the proportions tests p-val=0.2637 > α=0.05 Retain **H_0:** $\mu_P M = \mu_P F$, it can be said that (based on this sample) Males and Females tend to Frequently work out the same, on average based on this sample. According to the test the ~7% difference is estimates is not significant enough to prove that any population works out Frequently more than the other proportionately.