The Influence of Biological Sex on Human Body Part Ratios
How these Ratios Compare Between the Sexes

Kevin A. Black - kevin.black@wsu.edu *Washington State University Vancouver*

Throughout history, there have been evident traits of uniqueness among the multicellular organisms that roam the Earth. A common theme among these creatures relates to the differences in biological sexes, especially when it comes to size or behavior. In an endeavor to establish some distinct patterns between the biological sexes of humans, male and female, students of the STAT 419 course (Introduction to Multivariate Statistics) at Washington State University conducted a large-scale survey amongst each other and their peers. This brief survey was composed of body part measurements and other metrics like gender, ethniticty, eye color, age, and so on. The students recorded the data in a consistent format, which was then compiled by the instructor of the class, Monte Shaffer. After the compilation of data, students were free to formulate their own questions and look for recognizable patterns amongst the values. These students also practiced data provenance whilst conducting their research to make sure the body measurement data wasn't misused in the process.

For this research paper in particular, I address the topic of how biological sex influences the ratios of particular body parts. Specifically, this paper looks at the influence that being male or female has on two body measurement ratios: (1) the ratio of height and arm span and (2) the ratio of height and head height. The steps taken in this research involved performing a Pearson correlation test on the ratio of height and arm span, while a two-sample t-test was performed on the ratio of height and head height. The results of these tests found that while there was a noticeable variation in the measurements of male and female body parts, the previously mentioned ratios were very similar, which fall in line with our current body proportion knowledge for biological males and females.

Keywords: Shapiro-Wilk test, Pearson Product-Moment Correlation, null hypothesis, alternative hypothesis, two-sample t-test, data provenance.

November 05, 2020

1 Introduction

As a customary portion of the STAT 419 course at Washington State University, the course students involved were required to take part in a data collection/manipulation project involving the measurements of various body parts. Following the data collection, professor Monte Shaffer compiled all student contributions into a single, pipe-delimited text file whose explicit content is to remain confidential and only used for the sake of addressing the research questions presented in this paper.

After receiving the data set ($n = 428$) and cleaning up particular observations using a range of methodologies based on what I had in mind for how this data will be used, I determined that I would focus on what kind of influence biological sex has on certain human body part ratios. To supplement my inquiry of this data, I centered my research questions around particular parts of the human body, which would be *height*, *arm.span*, and *head.height* of the data set. These variables correspond to the standing height of the individual with no shoes on, the length from one middle finger to the other with fully extended arms, and the height from the top of the head to below the chin, respectively. Research questions pertaining to this study begins in section 3 and supportive R code can be found in section 6.3.

2 Data Description

As mentioned in the introduction, the data set utilized throughout this research paper was supplied through the combined efforts of professor Monte Shaffer and the students of the STAT 419 class at Washington State University. Each student was tasked with recording observations composed of 37 attributes from 10 different people, ideally with an even mix of males and females. For each observation (denoted as an individual person), there are measurements of body parts, data collector/respondent identifiers ran through a MD5 hash function, and general information about each respondent. Body part measurements were recorded with body measuring tape and in particular units up to the surveyor's personal choice (either inches or centimeters). For the sake of consistency throughout this research paper, all centimeter values were converted to inches and measurement values will be treated as inches from here on.

These observations were recorded in early September 2020 and compiled by the instructor for our use in late October 2020. Given that these observations were recorded amid the COVID-19 pandemic, each student was required to make a simple, yet descriptive handout that would detail how one would go about recording their own body measurements and the necessary values to take note of. This would be an ideal situation of how observations were recorded and sent electronically by each respondent, but observations could also be taken in person given that the surveyor and respondent were comfortable being in close proximity of each other. An example of a two-page handout created by Kevin Black, as well as further information regarding the attributes of this data set, can be found in Appendix 6.1.2 and Appendix 6.2, respectively.

On the surface, the purpose for writing this research paper and collecting the necessary data can simply be attributed to project requirements for a university course. However, the deeper reasoning behind why this research paper was created in the first place was to give students a more thorough understanding of the data analytics process. More specifically, how to not just work with the data, but how to understand the data and derive effective questions, what kind of data to wrangle for particular research, how to properly clean data, how to test for patterns and conclusions in a statistical, analytic environment, and how to exercise data provenance practices. This process will be very similar between all data focused projects in a data analyst's career, so this was a good starting point for garnering crucial experience.

3 How does being male or female influence the ratios between certain body parts?

Generally, making particular deductions about body measurements among males and females is more than likely due to the distinct physical patterns one can find when comparing the biological sexes. Those born biologically as males or females have about as many differing features to one another than their similar features, both internally and externally. Internally speaking, men typically have deeper voices, a faster metabolism, and can easily build muscle mass, whereas women possess a much more sophisticated reproductive system, possess the ability to breastfeed, and live longer on average (Wolchover 2011). Now what about externally? How does being male or female influence the ratios between certain body parts? The latter primary question will be elaborated through the following sub-questions, focusing on particular ratios that are likely to yield some insight on the different external measurements between males and females.

3.1 How does 'height' compare to 'arm span' between males and females?

The body part ratio between *height* and *arm.span* is a well-known one where "for most people, their arm span is about equal to their height. Mathematicians say the arm span to height ratio is one to one" (Brabandere 2017). To set up this sub-question, let's first declare some null and alternative hypotheses for males and females. For males, $H_0 : \rho_m = 0$ and $H_1 : \rho_m \neq 0$. For females, $H_0 : \rho_f = 0$ and $H_1 : \rho_f \neq 0$. We must also check both vectors for normality prior to correlation testing by performing a Shapiro-Wilk test with the `shapiro.test()` function. Running this function gives results for males *height* ($W = 0.73255$, $p = 2.303 \times 10^{-11}$) and *arm.span* ($W = 0.80943$, $p = 2.664 \times 10^{-9}$), as well as for females *height* ($W = 0.78534$, $p = 6.762 \times 10^{-11}$) and *arm.span* ($W = 0.82018$, $p = 8.305 \times 10^{-10}$). All of these test statistics show that we can move forward with the `cor.test()` function as each of these tested populations may come from normal distributions. The correlation test will be conducted using the method of Pearson Product-Moment Correlation.

Given the results of `cor.test()`, when it comes to males we reject our null hypothesis $H_0 : \rho_m = 0$ and accept our alternative hypothesis $H_1 : \rho_m \neq 0$ as there is some clear indication of strong, positive correlation among the male body parts ($t_{86} = 33.105$, $p < 2.2 \times 10^{-16}$). The same conclusion can be made with females, where we reject our null hypothesis $H_0 : \rho_f = 0$ and accept our alternative hypothesis $H_1 : \rho_f \neq 0$ ($t_{100} = 40.488$, $p < 2.2 \times 10^{-16}$). Based solely on figure 1 below that was generated from the R code in section 6.3.3, we can see that there are strong positive correlations for both males and females with regard to their respective *height* and *arm.span* values. Additionally, a table displaying the mean, standard deviation, and correlation values for the male and female body parts used in this study can be found in section 6.3.6.

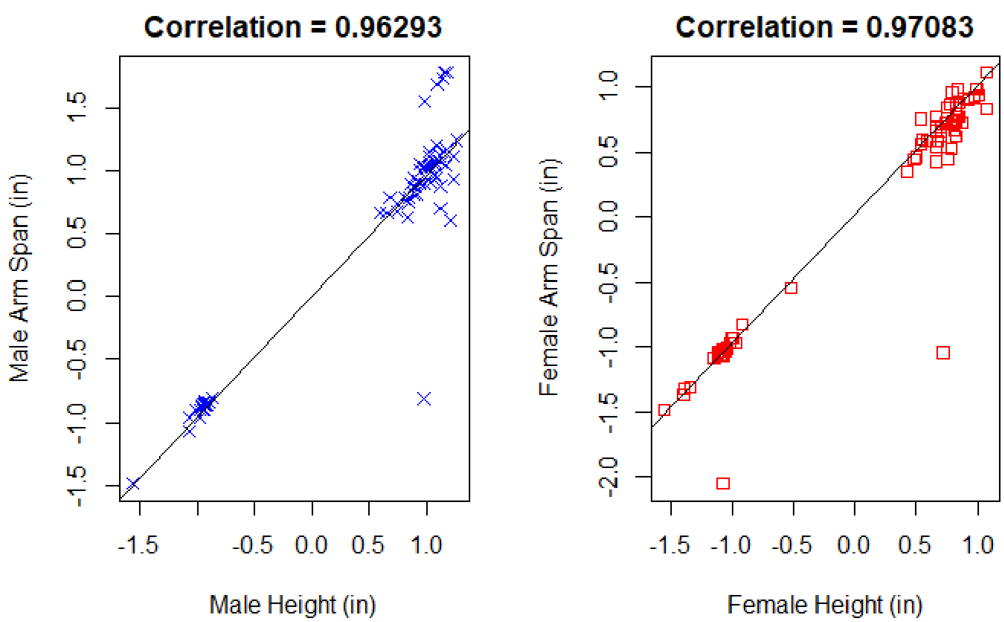


Figure 1: Plots/correlation values for males and females regarding *height* and *arm.span*.

3.2 How many average 'head height' lengths are males and females relative to their respective, average 'height'?

To form the foundation for how we'll go about answering this second sub-question, let's consider the population means for *head.height* and *height* for males and females. To test the two population means for equality between males and females, we will utilize a two-sample t-test. The null hypotheses and alternative hypotheses can be set up as follows:

- Regarding *head.height*, to determine if the population means for males and females are equal, let the null hypothesis be $H_0 : \mu_{m.head} = \mu_{f.head}$ and the alternative hypothesis be $H_1 : \mu_{m.head} \neq \mu_{f.head}$.
- Regarding *height*, to determine if the population means for males and females are equal, let the null hypothesis be $H_0 : \mu_{m.height} = \mu_{f.height}$ and the alternative hypothesis be $H_1 : \mu_{m.height} \neq \mu_{f.height}$.

Based on the two-sample t-test results generated by the code in section 6.3.4, regarding the comparison of mean *head.height* between males and females, we can reject our null hypothesis $H_0 : \mu_{m.head} = \mu_{f.head}$ and accept our null hypothesis $H_1 : \mu_{m.head} \neq \mu_{f.head}$ as there is evidence of at least one statistical difference in the mean head heights between the sexes ($t_{182.64} = 3.8231$, $p = 1.807 \times 10^{-4}$). And as for *height*, we can make a similar conclusion where we reject our null hypothesis $H_0 : \mu_{m.height} = \mu_{f.height}$ and accept our null hypothesis $H_1 : \mu_{m.height} \neq \mu_{f.height}$ as there is also evidence of at least one statistical difference in the mean heights between the sexes ($t_{184.65} = 3.9891$, $p = 9.552 \times 10^{-5}$).

Now that it's established that there are indeed statistical differences between males and females when it comes to their respective mean *head.height* and *height* values, we can calculate the explicit values to determine how many average *head.height* lengths males and females are relative to their respective, average *height*. From the results generated by the code in section 6.3.4, we can see that the average head height for males is 18.19722 inches and for females is 14.31103 inches, whereas the average height for males is 138.7041 inches and for females is 107.5450 inches. Using simple division, we can describe these *height* values in terms of *head.height* by calculating 138.7041/18.19722 for males and 107.5450/14.31103 for females. On average, this leads to males being 7.622273 heads tall and females 7.514837 heads tall.

4 Key Findings

For the first sub-question, the correlation between *height* and *arm.span* measured in at 0.96293 for males and ever-so-slightly higher at 0.97083 for females. These values mean that the heights and arm spans for both sexes change at almost the same rate as one another, indicating that there is little to no difference between males and females for this common body ratio. The only distinction between the sexes in this sample is that they operate on different value ranges, where height and arm span are larger for males than for females. As for the second sub-question, the surprisingly about-equal results of 7.622273 heads for males and 7.514837 heads for females lines up with common proportion knowledge about human height in terms of head height, where "the average adult human is technically seven-and-one-half heads tall... the average adult female is smaller than the average adult male, however you'll notice that they are both proportionately similar" (Larson 2014).

5 Conclusion

It's important to reiterate that there's no doubt that males and females can have quite stark differences when it comes to the measurements of external features, and the research conducted above shows that while there can be some differences, there are also some notable similarities. For the correlation values of these particular attributes and samples, it would appear that males and females are almost equally as likely to have a height matching their arm span. This shows that males and females can have a very similar body part ratio despite having varied body measurements. The research conducted for this sub-question is simply a supplement to information that has already been known throughout history and simply reaffirms the existing beliefs for this specific ratio of body parts. Lastly, for the heights of males and females measured in terms of their respective head heights, they once again both have very similar ratios despite them having very different average, respective values of *height* and *head.height*. The evidence provided shows that even though males and females can have varying body measurements between each other as a group, the influence of biological sex on human body part ratios is seemingly non-existent in the case of these attributes as the ratios were strikingly similar in both research questions.

6 APPENDICES

6.1 Data Provenance

6.1.1 Utilization of Data Provenance

While it could be seen as an application mainly used in large-scale data analytics projects, the multitude of steps to practice data provenance was also used to handle the vulnerable data used in this research. Auxiliary files such as the R project files can be found on the project repository through GitHub, while the specific functions used in this report can be found in the `functions-project-measure.R` file or in section 6.3.1[1]. The data set itself was not saved to any location online due to privacy concerns, but it was organized and saved onto a local hard drive for immediate use.

The collection and general organization process for the data set is thoroughly described in sections 2 and 6.2. Cleaning for the actual substance of the data set was performed through the use of the `prepareMeasureData()` function, where the data set was manipulated to more better fit the aims of addressing the particular research questions for this report. Cleaning this data set involved multiple steps, such as: omitting rows containing NA values based solely on the body measurement columns, setting a consistent naming convention for *gender* and *units*, converting all body measurement values to inches, and implementing the option for scaling the body measurement data. Despite the cleaning of all columns, the only attributes that kept the research questions in mind were retained, so the only measurement fields utilized were *height*, *arm.span*, *head.height*, and *gender*.

Prior to `prepareMeasureData()`, the data is imported via the `read.file()` function where it checks to see if a cleaned version of the data set already exists, to which that particular file would take precedence and be used[2]. If no clean version currently exists, the function goes through the cleaning process and saves the cleaned data set to the same directory as original data set, stored in path.to.secret. For unbiased samples of the data frame, a seed of 1 was set for reproducibility and 200 random observations were drawn without replacement.

The documented R code can be found in section 6.3. Key findings and visualizations of summary statistics were discussed previously throughout sections 3 through 4, as well as section 6.3.6. Based on the points made in this section, its clear that data provenance was kept in mind for making sure there was a traceable history in the usage of this data set, whether to resolve potential issues or to cut down on access times[3].

6.1.2 Data Collection Handout

Figure 2: Handout Page 1

PROJECT 1: "HANDOUT"

This handout is a prelude to a data collection project comprised of having 10 individuals record numerous measurements around their body (measured in **centimeters**), along with general information that does not require measuring. Your name will be encrypted using a hash function known as MD5, so your measurements and identifying data will remain confidential throughout the project. Below, you will find the various measurements you need to take, which could take 20+ minutes. Covariates labeled with (left, right) means you will need to measure both the left and right appendages for that field, separated by a comma. Diagrams are shown on the next page, which will show you how to take the measurements yourself for each field and are annotated by the abbreviations listed in the table below.

AREA FOR RESPONDENT

COVARIATE	***MEASUREMENT***
Name (first name, last initial)	
Dominant writing hand	
Dominant eye for seeing	
Eye color	
Dominant swinging hand	
Age	
Gender	
Ethnicity	
Height *Standing height of the individual with no shoes on. H on diagram.*	
Head height *Height from the top of the head to below the chin. HH on diagram.*	
Head circumference Distance around the head, measured above the eyes/ears. HC on diagram.	
Hand length (left, right) *Length of the hand from the middle finger to the wrist (just below the palm). HL on diagram.*	
Hand width (left, right) *Width of a fully stretched hand from the pinky finger to the thumb. HW on diagram.*	
Hand to elbow (left, right) *Length from the middle finger to the elbow. HE on diagram.*	
Elbow to armpit (left, right) *Length from the elbow to the arm pit. EA on diagram.*	
Arm reach (left, right) *Length from floor to the extended arm maximum point, standing flatfooted. AR on diagram.*	
Arm span *Length from each middle finger, with fully extended arms. AS on diagram.*	
Foot length (left, right) *Length of the foot from the largest toe to the back of the heel. FL on diagram.*	
Floor to knee pit (left, right) *Distance from the floor to the knee pit. FK on diagram.*	
Floor to hip (left, right) *Distance from the floor to the hip. FH on diagram.*	
Floor to navel *Distance from the floor to the navel (belly button). FN on diagram.*	
Floor to armpit (left, right) *Distance from the floor to the arm pit. FA on diagram.*	

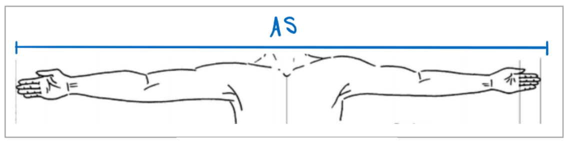
Kevin Black – kevin.black@wsu.edu

Figure 3: Handout Page 2

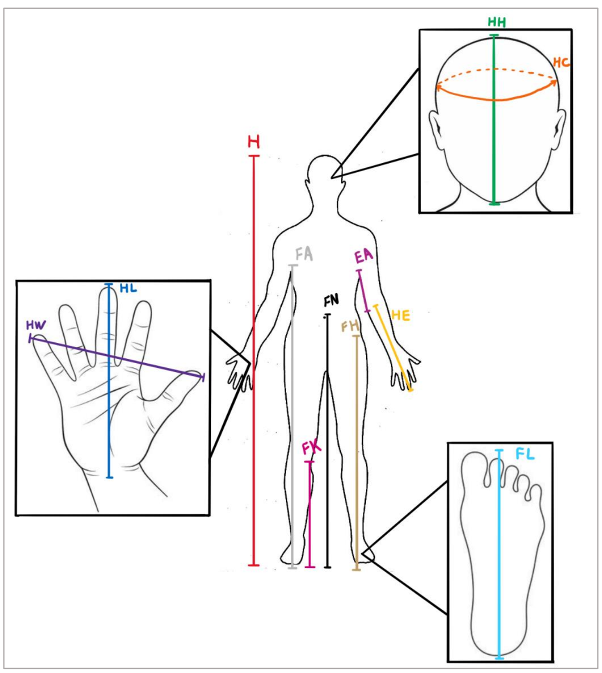
PROJECT 1: "HANDOUT"

DATA COLLECTOR USE ONLY

COVARIATE	***EVALUATION***
Quality (1-10)	
Minutes	
To be completed later?	
Notes	



How to measure arm span.



How to measure height, head height, head circumference, hand length, hand width, hand to elbow, elbow to armpit, foot length, floor to knee pit, floor to hip, floor to navel, and floor to armpit.

How to measure arm reach.

Kevin Black – kevin.black@wsu.edu

6.2 *Data Set Explained*

In addition to how the data set was described in Section 2, explanations regarding each attribute can be found below. After the collaborative effort of all students having their data compiled, the data set ended up having 428 total observations. However, the data set was filled with an enormous amount of NA values in the body measurements, potentially due to the time constraints of some students or lack of attempt to fill out all fields. As a result, running the function `complete.cases()` on the data set during the data cleaning process returned a data frame containing only 262 observations, about 61.21% of the original data set size. `complete.cases()` was used over `na.omit()` because the latter function would omit all rows containing NA values based on all columns, including the rows where the non-body measurement attributes had NA values, whereas the former function would omit NA values only for the specified body measurement columns.

Figure 4: Description of Each Field

Field	Description
data_collector	MD5 encryption of surveyor identifier.
person_id	MD5 encryption of respondent identifier.
side	Body part side being measured; left, right, or NA.
height	Standing height of the individual with no shoes on.
head.height	Height from the top of the head to below the chin.
head.circumference	Distance around the head, measured above the eyes/ears.
hand.length	Length of the hand from the middle finger to the wrist (just below the palm).
hand.width	Width of a fully stretched hand from the pinky finger to the thumb.
hand.elbow	Length from the middle finger to the elbow.
elbow.armpit	Length from the elbow to the arm pit.
arm.reach	Length from floor to the extended arm maximum point, standing flatfooted.
arm.span	Length from one middle finger to the other, with fully extended arms.
foot.length	Length of the foot from the largest toe to the back of the heel.
floor.kneepit	Distance from the floor to the knee pit.
floor.hip	Distance from the floor to the hip.
floor.navel	Distance from the floor to the navel (belly button).
floor.armpit	Distance from the floor to the arm pit.
units	Units used in measuring body parts; centimeters or inches.
writing	Dominant hand of respondent; left or right.
eye	Dominant eye of respondent; left, right, or both.
eye_color	Eye color of respondent.
swinging	Swinging hand or respondent; left or right.
age	Age of respondent.
gender	Specified gender of respondent; male or female (non-binary in one case).
quality	Quality of testing decided by surveyor; on a scale of 1-10.
minutes	Minutes spent performing measurements.
ethnicity	Ethnicity of respondent.
notes	Supplementary notes pertaining to observation.

6.3 R Code Used for Research

6.3.1 Sourced Functions

```
prepareMeasureData = function(measure,scale){
  # Cleaning: omit NA rows based measured values, not on $side
  measure = measure[complete.cases(measure[,4:26]),]

  # Cleaning: consistent naming convention
  measure$gender = factor(tolower(measure$gender))
  measure$gender[measure$gender=="f"] = "female"
  measure$gender[measure$gender=="m"] = "male"
  measure$units = factor(tolower(measure$units))
  measure$units[measure$units=="inches"] = "in"
  measure$units[measure$units=="inch"] = "in"
  measure$units[measure$units=="\"in\""] = "in"
  measure$units[measure$units=="cm"] = "in"

  # Converting cm to inches
  for(row in 1:nrow(measure)){
    if(measure[row,]$units=="cm"){
      measure[row,4:26] <- measure[row,4:26]/2.54
    }
  }

  # Scale data if scale = TRUE
  if(scale){
    measure[,4:26] <- scale(measure[,4:26])
    return(measure)
  } else{ # If false, return without scaling
    return(measure)
  }
}

read.file = function(path,scale){
  tryCatch(
    expr = {
      # Open cleaned file if already available
      measure = utils::read.csv(paste0(path.to.secret,"measure-clean.txt"),
                                header = TRUE, quote = "", sep = "|")
      return(measure)
    },
    warning = function(w){
      # If no clean file, open original file
      measure = utils::read.csv(paste0(path.to.secret,"measure-students.txt"),
                                header = TRUE, quote = "", sep = "|")
      # Clean data
      measure = prepareMeasureData(measure,scale)

      # Save cleaned data for later
      write.table(measure,paste0(path.to.secret,"measure-clean.txt"),sep="|",quote=FALSE)
      return(measure)
    }
  )
```

```
}
```

6.3.2 Libraries, Sourcing Functions, Isolating Sexes

```
# Import necessary libraries
library(stats) # For cor()
library(devtools) # For source_url()
library(humanVerseWSU)
library(Hmisc)

# Source cleaning function
path.hub = "https://raw.githubusercontent.com/KevnBlack/WSU_STATS419_FALL2020/"
source_url(paste0(path.hub,"master/functions/functions-project-measure.R"))

# Source Monte Shaffer function which builds correlation table
path.humanVerseWSU = "https://raw.githubusercontent.com/MonteShaffer/humanVerseWSU/"
source_url(paste0(path.humanVerseWSU,"master/misc/functions-project-measure.R"))
path.to.secret = "D:/School/Fall 2020/STAT 419/datasets/"

# If changing scale value, be sure to remove previous measure file from working directory
measure.df = read.file(path.to.secret,FALSE) # Import data without scaling
set.seed(1) # Sample 200 observations from data frame
measure.sample = measure.df[sample(nrow(measure.df),200),]

# Isolate male and female data
measure.df.m = measure.sample[measure.sample$gender == "male",]
measure.df.f = measure.sample[measure.sample$gender == "female",]
```

6.3.3 First Research Subquestion

```
# Checking for normality
shapiro.test(measure.df.m$height.NA)
shapiro.test(measure.df.m$arm.span.NA)
shapiro.test(measure.df.f$height.NA)
shapiro.test(measure.df.f$arm.span.NA)

# Correlation values between height and arm span
cor.m.has = cor.test(measure.df.m$height.NA, measure.df.m$arm.span.NA)
cor.f.has = cor.test(measure.df.f$height.NA, measure.df.f$arm.span.NA)

# Graphs with correlation values and trend lines, for males and females
par(mfrow = c(1,2))
plot(measure.df.m$height.NA, measure.df.m$arm.span.NA,
     main = paste("Correlation =", round(cor.m.has$estimate,5)), pch = 4,
     xlab = "Male Height (in)", ylab = "Male Arm Span (in)", col = "blue")
abline(lm(measure.df.m$height.NA ~ measure.df.m$arm.span.NA))

plot(measure.df.f$height.NA, measure.df.f$arm.span.NA,
     main = paste("Correlation =", round(cor.f.has$estimate,5)), pch = 0,
     xlab = "Female Height (in)", ylab = "Female Arm Span (in)", col = "red")
abline(lm(measure.df.f$height.NA ~ measure.df.f$arm.span.NA))
```

6.3.4 Second Research Subquestion

```
# Checking for normality
shapiro.test(measure.df.m$head.height.NA)
shapiro.test(measure.df.m$height.NA)
shapiro.test(measure.df.f$head.height.NA)
shapiro.test(measure.df.f$height.NA)

# T.test to compare means of populations
t.test(measure.df.m$head.height.NA, measure.df.f$head.height.NA)
t.test(measure.df.m$height.NA, measure.df.f$height.NA)

## How many 'heads' on average is a male relative to their 'height'?
mean(measure.df.m$height.NA)/mean(measure.df.m$head.height.NA)
## How many 'heads' on average is a female relative to their 'height'?
mean(measure.df.f$height.NA)/mean(measure.df.f$head.height.NA)
```

6.3.5 Correlation Table Creation

```
# Set up paths for tables
path.project = "D:/School/Fall 2020/STAT 419/git/WSU_STATS419_FALL2020/PROJECT-01/"
path.tables = paste0(path.project,"tables/")
  createDirRecursive(path.tables)

file.correlation = paste0(path.tables,"measure-table-m.tex")
myData = as.matrix(measure.df.m[,c("height.NA","head.height.NA","arm.span.NA")])

# Create male table
buildLatexCorrelationTable(myData,
  rotateTable = FALSE,
  width.table = 0.95, # 0.95 when rotateTable is FALSE, 0.60 when TRUE
  myFile = file.correlation,
  myNames = c("Height (in)", "Head Height (in)", "Arm Span (in)"),
  myCaption = "Descriptive Statistics and Correlation Analysis for Males")

Sys.sleep(2) # Error checking when knitting-to-pdf

file.correlation = paste0(path.tables,"measure-table-f.tex")
myData = as.matrix(measure.df.f[,c("height.NA","head.height.NA","arm.span.NA")])

# Repeat for females
buildLatexCorrelationTable(myData,
  rotateTable = FALSE,
  width.table = 0.95,
  myFile = file.correlation,
  myNames = c("Height (in)", "Head Height (in)", "Arm Span (in)"),
  myCaption = "Descriptive Statistics and Correlation Analysis for Females")

Sys.sleep(2)
```

6.3.6 *Tables of Descriptive Statistics and Correlations*

Table 1: Descriptive Statistics and Correlation Analysis for Males

		M	SD	1	2
1	**Height (in)**	138.7	53.34	1	
2	**Head Height (in)**	18.2	7.06	.97***	1
3	**Arm Span (in)**	140.1	55.67	.96***	.90***

Notes: Pearson pairwise correlations are reported;
a two-side test was performed to report correlation significance.

$^{\dagger}p < .10$ $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table 2: Descriptive Statistics and Correlation Analysis for Females

		M	SD	1	2
1	**Height (in)**	107.5	54.08	1	
2	**Head Height (in)**	14.3	6.90	.96***	1
3	**Arm Span (in)**	105.2	55.84	.97***	.94***

Notes: Pearson pairwise correlations are reported;
a two-side test was performed to report correlation significance.

$^{\dagger}p < .10$ $^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

ENDNOTES

[1] The buildLatexCorrelationTable() function was a crucial function that was used to construct the table found in section 6.3.6, but it was omitted from appearing in section 6.3.1 due to the length of the code involved. Instead, code for this function can be found on Monte Shaffer's Github repository through this link.

[2] As mentioned in a comment in section 6.3.2, if you are going to change the *scale* value from TRUE to FALSE or vice versa when invoking read.file(), be sure to remove the previous measure file from whatever you set the working directory to in the *path.to.secret* variable. This is because no feature was implemented to remove the previous file after switching the value of *scale* due to time constraints.

[3] Access times were not a huge problem for this data set as the original size of the data set was only composed of 428 observations and the research code was executed on a fairly high-end computer, however it makes for good practice when it comes time to work on larger data sets down the road.

REFERENCES

Brabandere, Sabine De. 2017. Human body ratios. (Accessed: October 31, 2020). https://bit.ly/2HLPqNb.

Larson, Devin. 2014. Standard proportions of the human body. (Accessed: October 31, 2020). https://bit.ly/3kSvTc3.

Wolchover, Natalie. 2011. Men vs. women: Our key physical differences explained. (Accessed: November 1, 2020). https://bit.ly/388izNn.

TABLE OF CONTENTS