Stats 141SL Thyroid Eye Disease Volume - Final

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Cleaning up the data (Yi Ai)

```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
# read data, deleted hidden cols via excel - yiai
#setwd("~/Desktop/School/STATS 141SL/Final Project")
#TEDV_visible_cols <- read.csv("TEDV.csv")

# read data, deleted hidden cols via excel
TEDV_visible_cols <- read.csv(file = "TEDV.csv")

# new `control` patient variable
control <- c(rep(0, 24), rep(1, 21)) # 24 patients, 21 control obs
TEDV_visible_cols <- cbind(TEDV_visible_cols, control)

# replicate observations that are non-control
TEDV_replicated <- rbind(TEDV_visible_cols, TEDV_visible_cols[1:24,])

# rows 1:24 will be OD, rows 25:69 will be OS. label OD = 0, OS = 1 (use OS for control obs)
OD_or_OS <- c(rep(0, 24), rep(1, 45))

# make a new variable optic_neuropathy (present if 12th var is 0, 1 or 2)
optic_neuropathy <- rep(NA, 69)

for(i in 1:24) {
  if(is.na(TEDV_replicated[i, 12])){
    optic_neuropathy[i] <- 0
  }
  else if(TEDV_replicated[i,12] == 0) {
    optic_neuropathy[i] <- 1
  }
  else if(TEDV_replicated[i,12] == 2) {
    optic_neuropathy[i] <- 1
  }
  else {
```

```
    optic_neuropathy[i] <- 0
  }
}

for(i in 25:69) {
  if(is.na(TEDV_replicated[i, 12])){
    optic_neuropathy[i] <- 0
  }
  else if(TEDV_replicated[i,12] == 1) {
    optic_neuropathy[i] <- 1
  }
  else if(TEDV_replicated[i,12] == 2) {
    optic_neuropathy[i] <- 1
  }
  else {
    optic_neuropathy[i] <- 0
  }
}

sum(optic_neuropathy) # should be 9
```

```
## [1] 9
```

```
# combine cols
TEDV_replicated <- cbind(TEDV_replicated, OD_or_OS, optic_neuropathy)

# make new cols!
lagophthalmos <- c(TEDV_replicated[1:24, 4], TEDV_replicated[25:69, 5])
hertel <- c(TEDV_replicated[1:24, 6], TEDV_replicated[25:69, 7])
# strabismus # don't need to fix, applies to both eyes
medial_bow <- c(TEDV_replicated[1:24, 14], TEDV_replicated[25:69, 15])
decompression <- c(TEDV_replicated[1:24, 16], TEDV_replicated[25:69, 17])
fat_volume <- c(TEDV_replicated[1:24, 18], TEDV_replicated[25:69, 19])
muscle_volume <- c(TEDV_replicated[1:24, 20], TEDV_replicated[25:69, 21])
orbit_volume <- c(TEDV_replicated[1:24, 22], TEDV_replicated[25:69, 23])
FV.OV <- c(TEDV_replicated[1:24, 24], TEDV_replicated[25:69, 25])
MV.OV <- c(TEDV_replicated[1:24, 26], TEDV_replicated[25:69, 27])
medial_rectus_muscle_vol <- c(TEDV_replicated[1:24, 28], TEDV_replicated[25:69, 29])

TEDV <- cbind(TEDV_replicated[,c(1,2,3,8,9,10,13,30,31,32)],lagophthalmos,  hertel,medial_bow,decompres

# make new var: fat volume / muscle volume
fat_muscle_ratio <- TEDV$fat_volume/TEDV$muscle_volume

TEDV <- cbind(TEDV, fat_muscle_ratio)

TEDV %>% group_by(control) %>% summarise(avg_fat_volume = mean(fat_volume, na.rm = TRUE))
```

```
## # A tibble: 2 x 2
##   control avg_fat_volume
##     <dbl>          <dbl>
## 1       0       8365.816
## 2       1       6699.896
```

```r
TEDV %>% group_by(control) %>% summarise(avg_muscle_volume = mean(muscle_volume, na.rm = TRUE))
```

```
## # A tibble: 2 x 2
##   control avg_muscle_volume
##     <dbl>             <dbl>
## 1       0         11544.026
## 2       1          7897.825
```

```r
TEDV %>% group_by(control) %>% summarise(avg_orbit_volume = mean(orbit_volume, na.rm = TRUE))
```

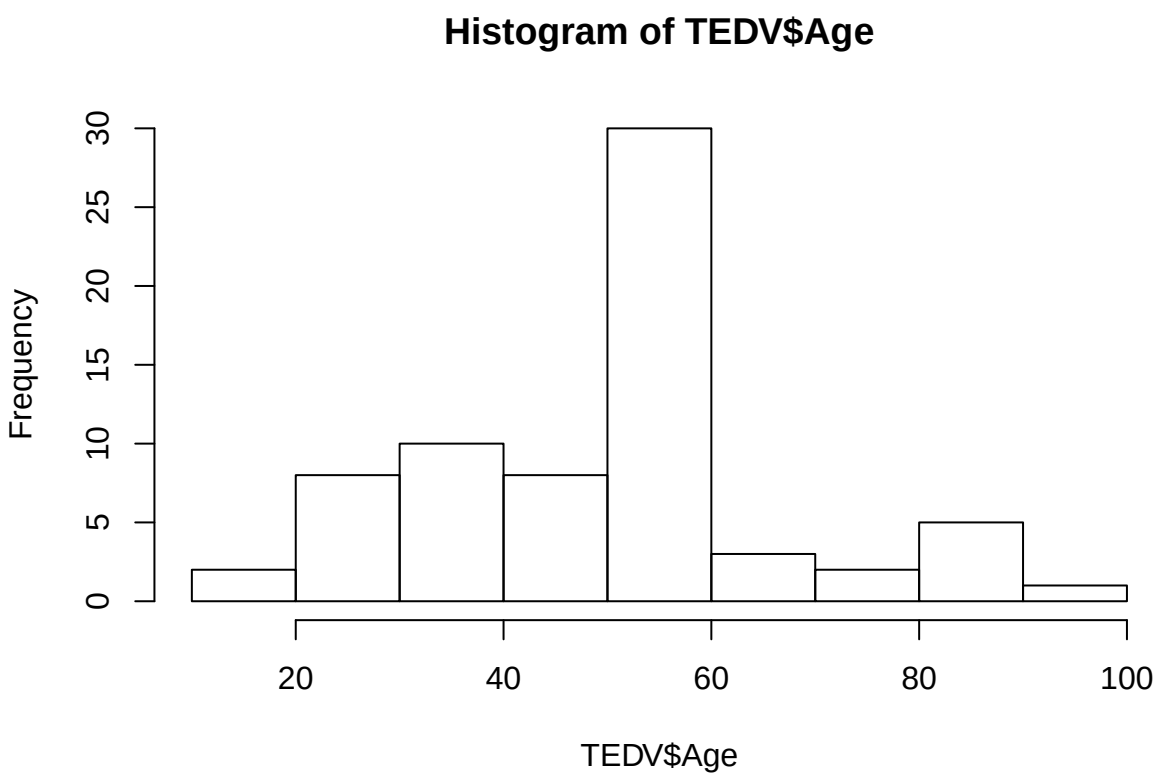
```
## # A tibble: 2 x 2
##   control avg_orbit_volume
##     <dbl>            <dbl>
## 1       0         24763.24
## 2       1         22160.14
```

```r
TEDV %>% group_by(control) %>% summarise(avg_medial_rectus_volume = mean(medial_rectus_muscle_vol, na.r
```

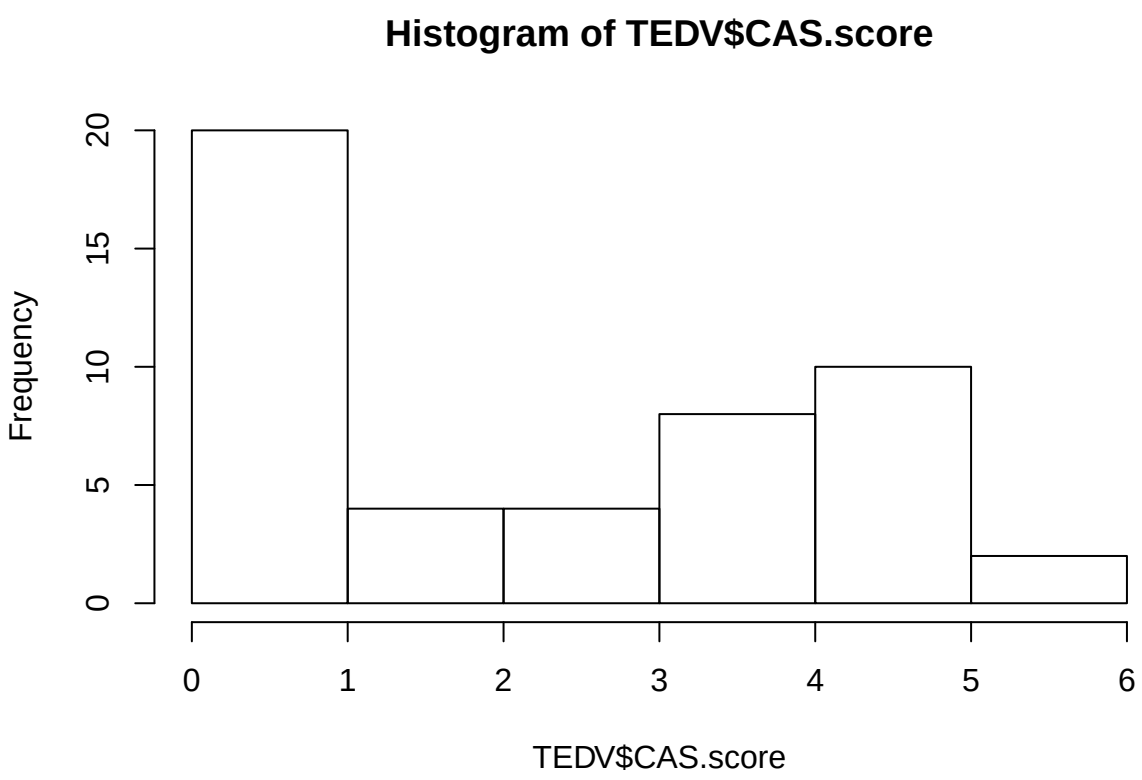
```
## # A tibble: 2 x 2
##   control avg_medial_rectus_volume
##     <dbl>                    <dbl>
## 1       0                 2081.173
## 2       1                  837.308
```

Exploration of data (Yi Ai)

```r
# histograms of numerical values
hist(TEDV$Age)
```



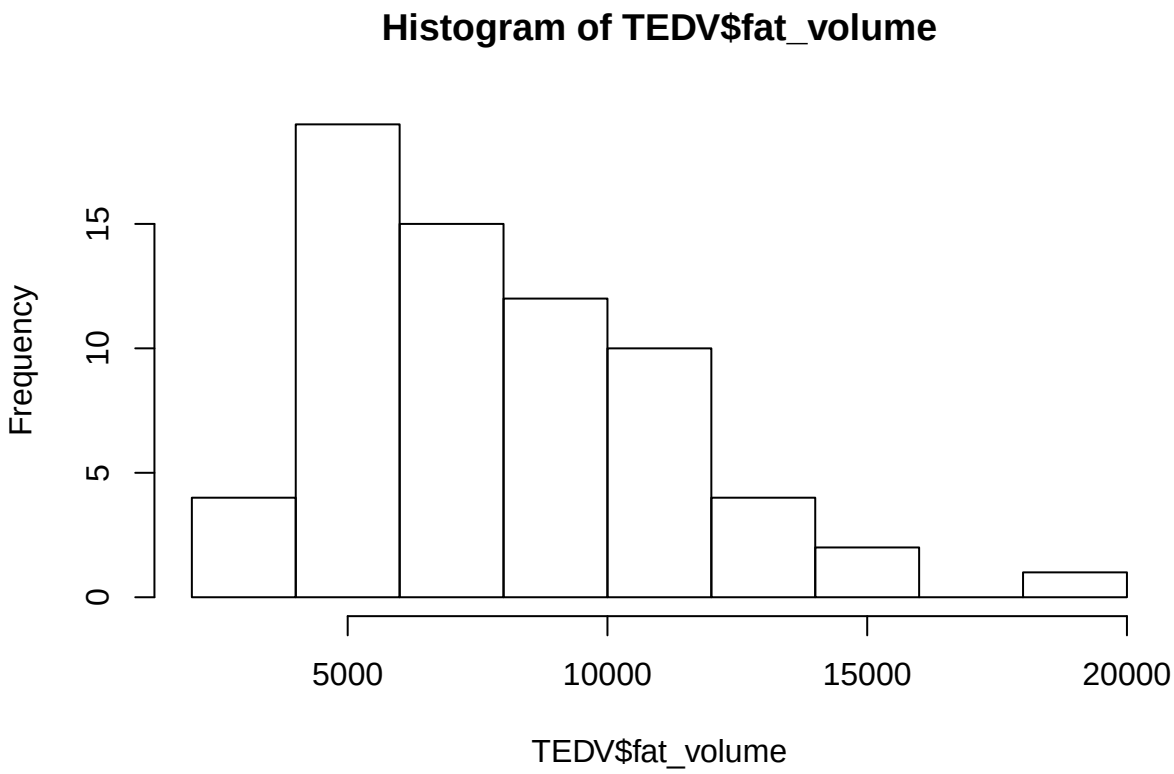

```
hist(TEDV$CAS.score)
```



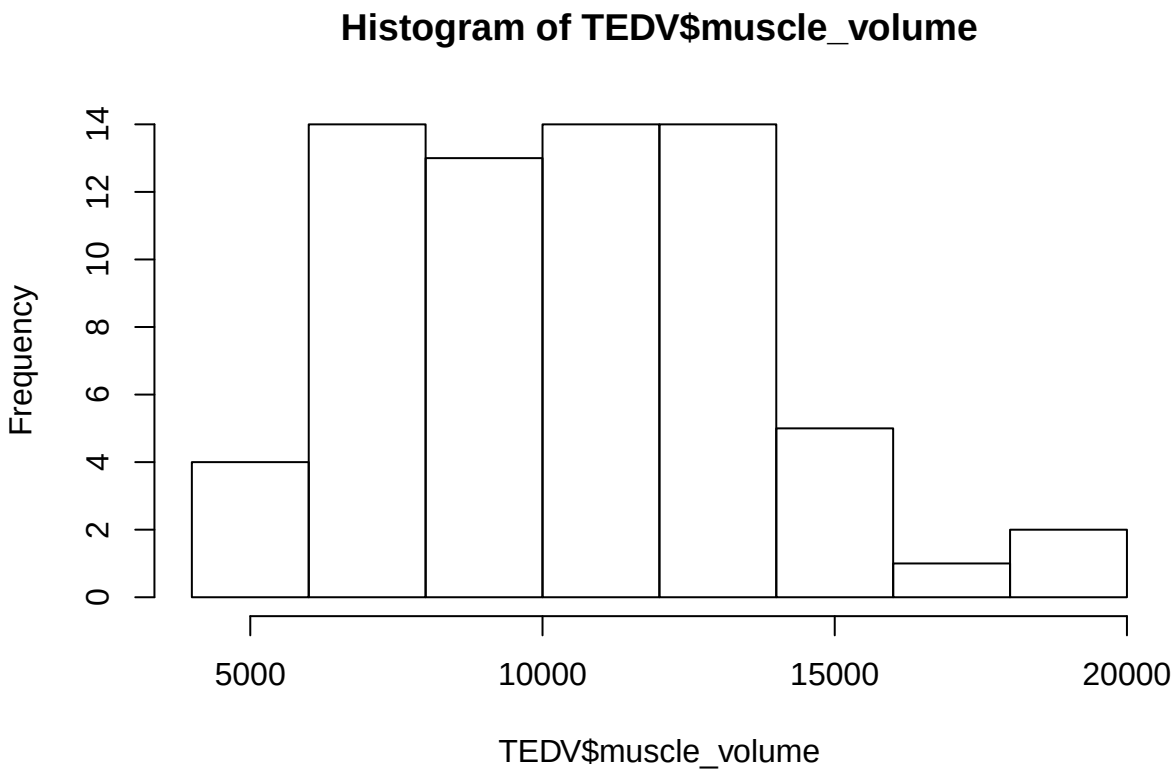

```
hist(TEDV$OSDI.score)
```


```
hist(TEDV$hertel)
```

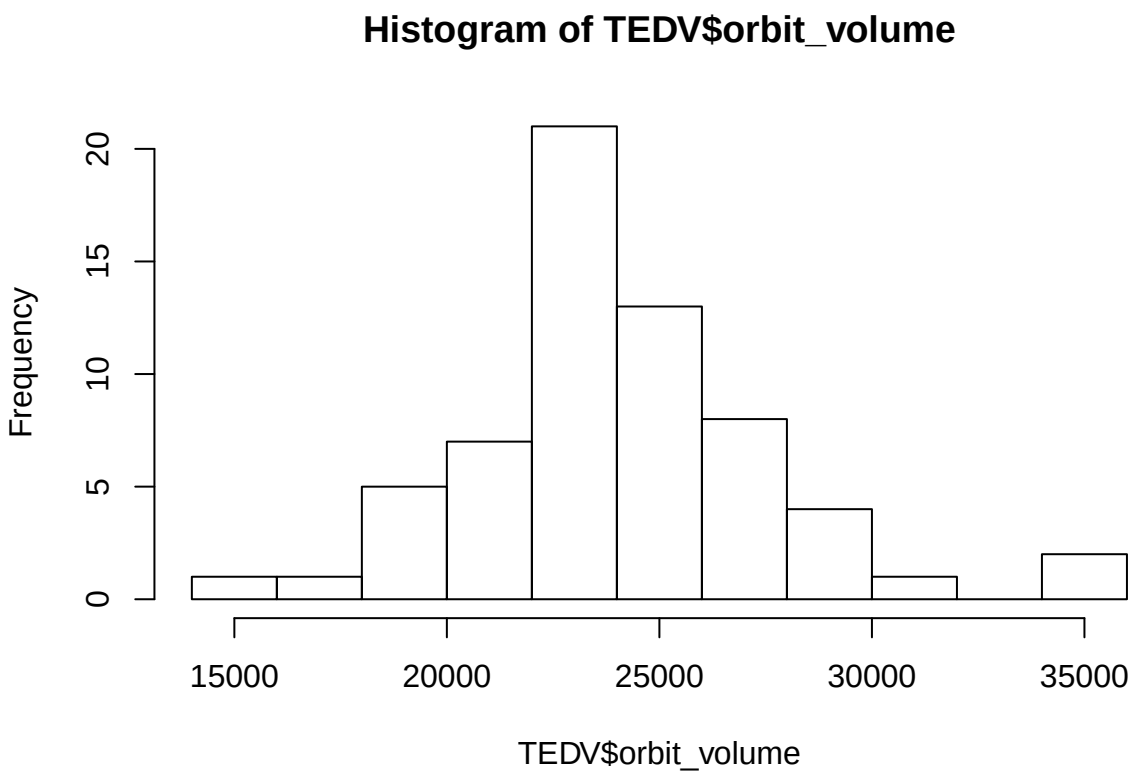

```
hist(TEDV$fat_volume)
```



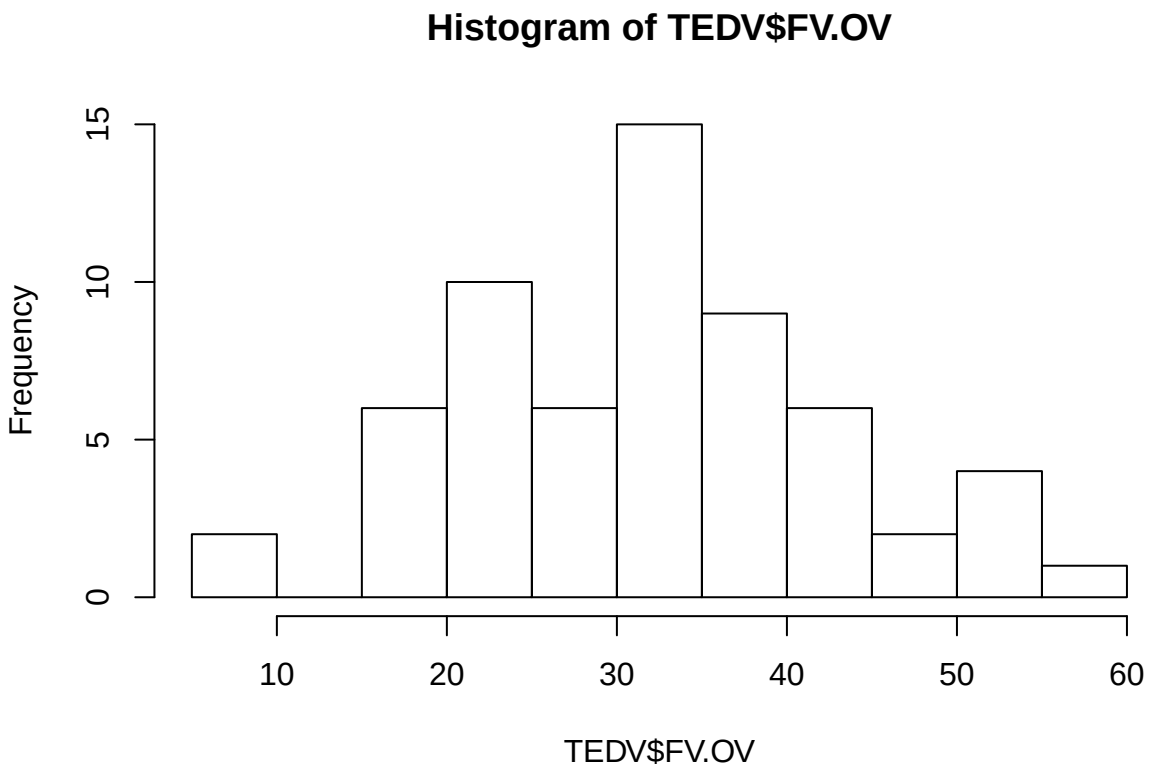

```
hist(TEDV$muscle_volume)
```




```
hist(TEDV$orbit_volume)
```

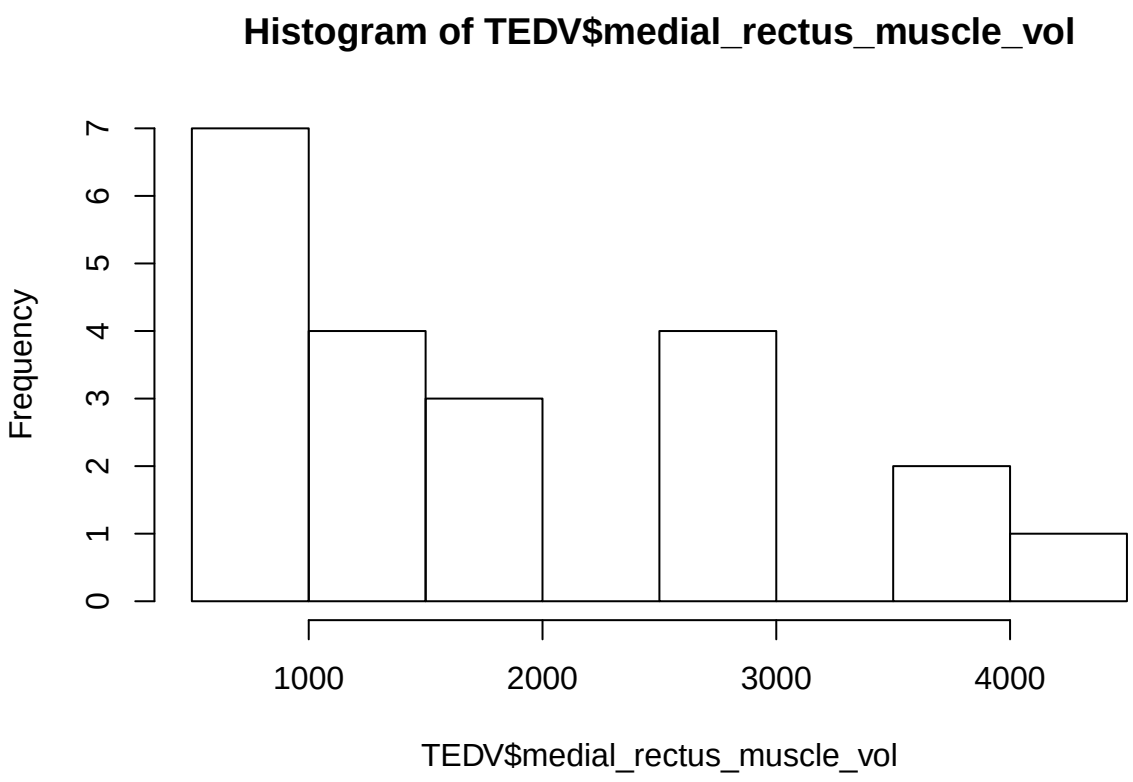



```
hist(TEDV$FV.OV)
```




```
hist(TEDV$MV.OV)
```


```
hist(TEDV$medial_rectus_muscle_vol)
```




```
hist(TEDV$fat_muscle_ratio)
```


```
# contingency table between optic neuropathy (ON) and logistic/categorical predictors
ON <- factor(TEDV$optic_neuropathy)
strabismus <- factor(TEDV$Strabismus.0.No.1.yes)
table(ON, strabismus)
```

```
##    strabismus
## ON   0  1
##   0 16 23
##   1  4  5
```

```
lagophthalmos <- factor(TEDV$lagophthalmos)
table(ON, lagophthalmos)
```

```
##    lagophthalmos
## ON   0 0.45 0.5  1 1.5  2
##   0 19    0   2 10   0  4
##   1  2    1   0  0   1  1
```

```
medial_bow <- factor(TEDV$medial_bow)
table(ON, medial_bow)
```

```
##    medial_bow
## ON   0  1
##   0 28  7
##   1  2  3
```

```
decompression <- factor(TEDV$decompression)
table(ON, decompression)
```

```
##    decompression
## ON   0  1
##   0 21 14
##   1  1  4
```

```
names(TEDV)
```

```
##  [1] "Time.of.Image...Date.of.visit" "Age"
##  [3] "CAS.score"                     "OSDI.score"
##  [5] "baseline.visit.date"           "time.from.onset"
##  [7] "Strabismus.0.No.1.yes"         "control"
##  [9] "OD_or_OS"                      "optic_neuropathy"
## [11] "lagophthalmos"                 "hertel"
## [13] "medial_bow"                    "decompression"
## [15] "fat_volume"                    "muscle_volume"
## [17] "orbit_volume"                  "FV.OV"
## [19] "MV.OV"                         "medial_rectus_muscle_vol"
## [21] "fat_muscle_ratio"
```

Using Fisher's Exact Test for testing the null independence of rows and columns in contingency tables for categorical variables (Yi Ai)

```
mat_ON_strab <- as.matrix(table(ON, strabismus))
fisher.test(mat_ON_strab)
```

```
##
##  Fisher's Exact Test for Count Data
##
## data:  mat_ON_strab
## p-value = 1
## alternative hypothesis: true odds ratio is not equal to 1
## 95 percent confidence interval:
##  0.1590346 5.1201667
## sample estimates:
## odds ratio
##   0.872122
```

```
mat_ON_lago <- as.matrix(table(ON, lagophthalmos)) ## too few elements in the matrix, many have 0
fisher.test(mat_ON_lago)
```

```
##
##  Fisher's Exact Test for Count Data
##
## data:  mat_ON_lago
## p-value = 0.02985
## alternative hypothesis: two.sided
```

```
mat_ON_med <- as.matrix(table(ON, medial_bow))
fisher.test(mat_ON_med)
```

```
##
##  Fisher's Exact Test for Count Data
##
## data:  mat_ON_med
```

```
## p-value = 0.08929
## alternative hypothesis: true odds ratio is not equal to 1
## 95 percent confidence interval:
##   0.5412784 80.0689978
## sample estimates:
## odds ratio
##   5.657694
```

```
mat_ON_decomp <- table(ON, decompression) ## advised that decompression is not a good predictor of ON, r
fisher.test(mat_ON_decomp)
```

```
##
##  Fisher's Exact Test for Count Data
##
## data:  mat_ON_decomp
## p-value = 0.1554
## alternative hypothesis: true odds ratio is not equal to 1
## 95 percent confidence interval:
##    0.5001107 308.6522623
## sample estimates:
## odds ratio
##   5.747191
```

Results: all p-values not significant, 95% confidence intervals all contain 1. This tells us that we cannot reject the null hypothesis of independence between ON and strabismus, ON and medial bowing, and ON and decompression.

Left versus Right Eye (Mrinalini)

```
library(ggplot2)

#Separate table for experimental data:
TEDV %>% filter( control== 0) -> tedv_exp
tedv_exp$OD_or_OS<- as.factor(tedv_exp$OD_or_OS)

# Getting some summary stats for left versus right

# In experiment group
TEDV %>% filter( control== 0, OD_or_OS==1) %>% summarise(count=n(), CAS= mean(CAS.score,na.rm= T), OSDI=
```

```
##   count    CAS    OSDI Strabismus_prop ON_prop lagophthalmos  hertel
## 1    24 2.6667 48.0208          0.5833   0.125           0.5 21.8542
##   medial_bow_prop decompression fat_volume muscle_volume orbit_volume
## 1             0.2          0.45   8868.116      11307.66     24856.61
##     FV.OV   MV.OV Medial_vol
## 1 34.9509 46.8726   1904.092
```

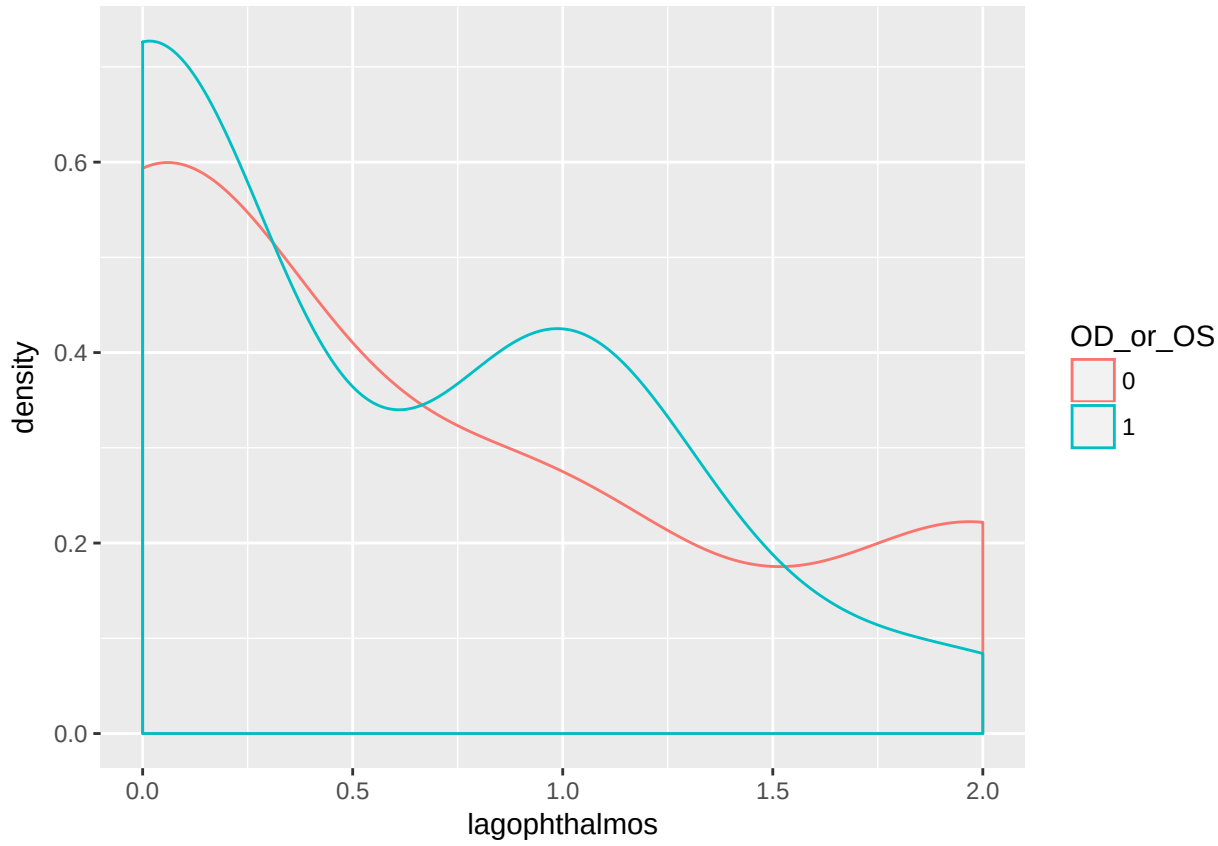
```
TEDV %>% filter( control== 0, OD_or_OS==0) %>% summarise( count=n(), CAS= mean(CAS.score,na.rm= T), OSDI
```

```
##   count    CAS    OSDI Strabismus_prop ON_prop lagophthalmos  hertel
## 1    24 2.6667 48.0208          0.5833    0.25        0.6475 22.3542
##   medial_bow_prop decompression fat_volume muscle_volume orbit_volume
## 1             0.3          0.45   7863.517      11780.39     24669.86
##    FV.OV   MV.OV Medial_vol
```

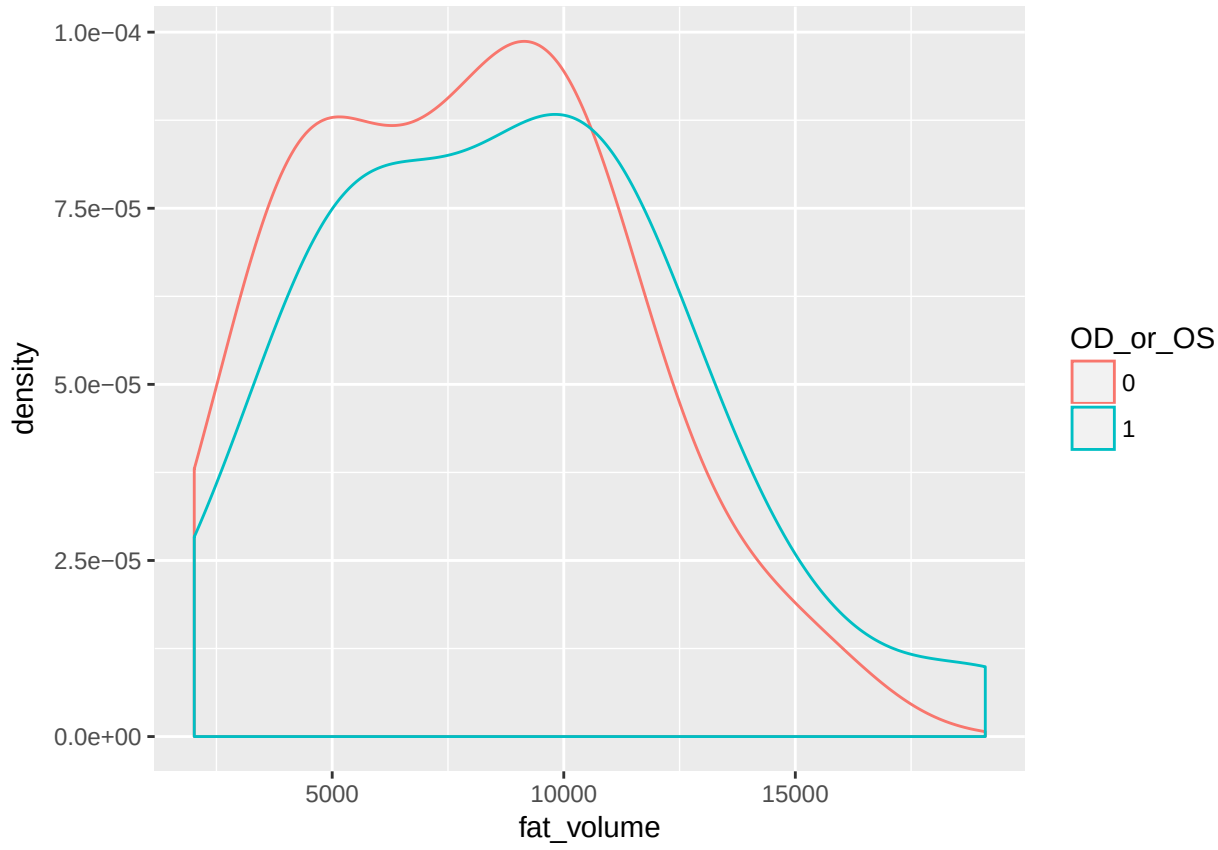
```
## 1 30.764 49.8548   2258.253
```

```
# Visualising and testing for significance in numerical variables:
#QUESTIONS: Is decompression carried out for both eyes?

#CAS_score, OSDI, strabismus, decompression-- Same for both eyes

# Lagopthalmos
ggplot(tedv_exp, aes(x=lagophthalmos, colour= OD_or_OS)) + geom_density(alpha= 0.1)
```

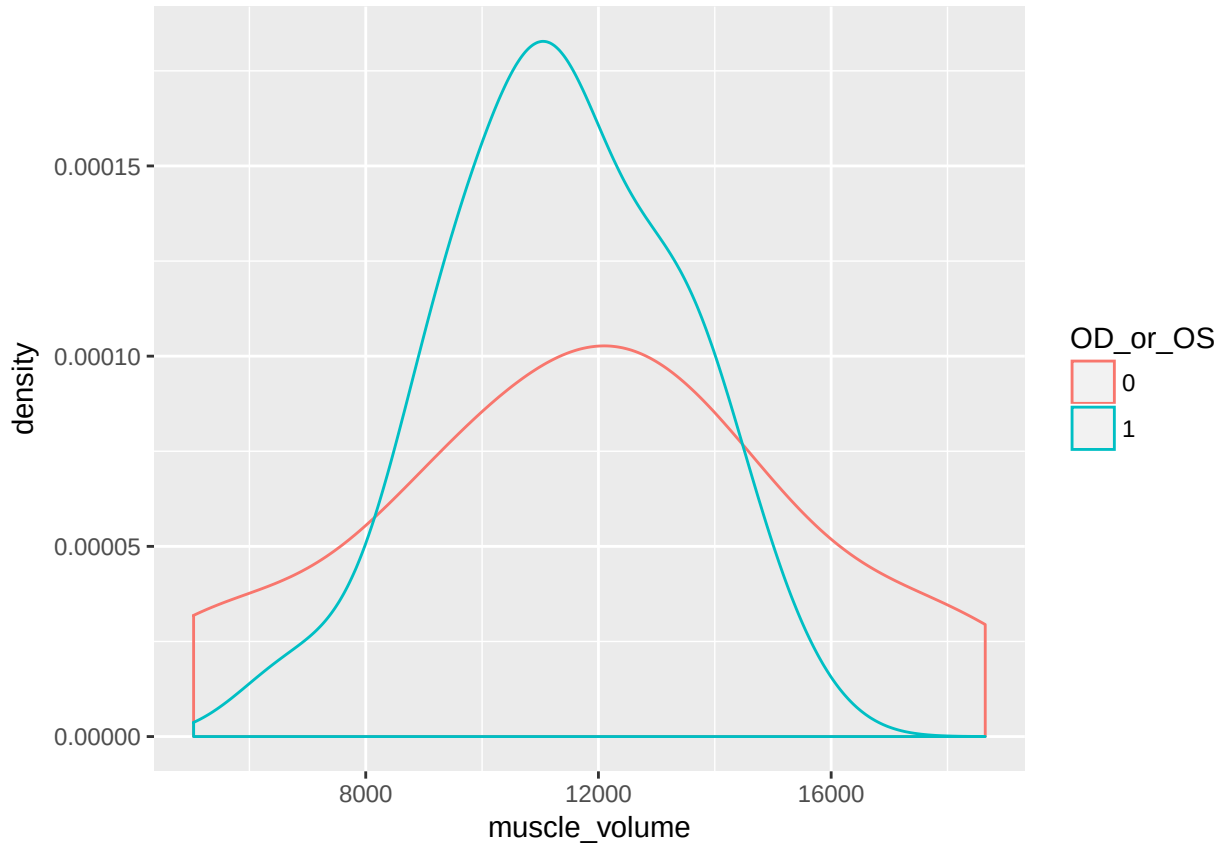
```
## Warning: Removed 8 rows containing non-finite values (stat_density).
```



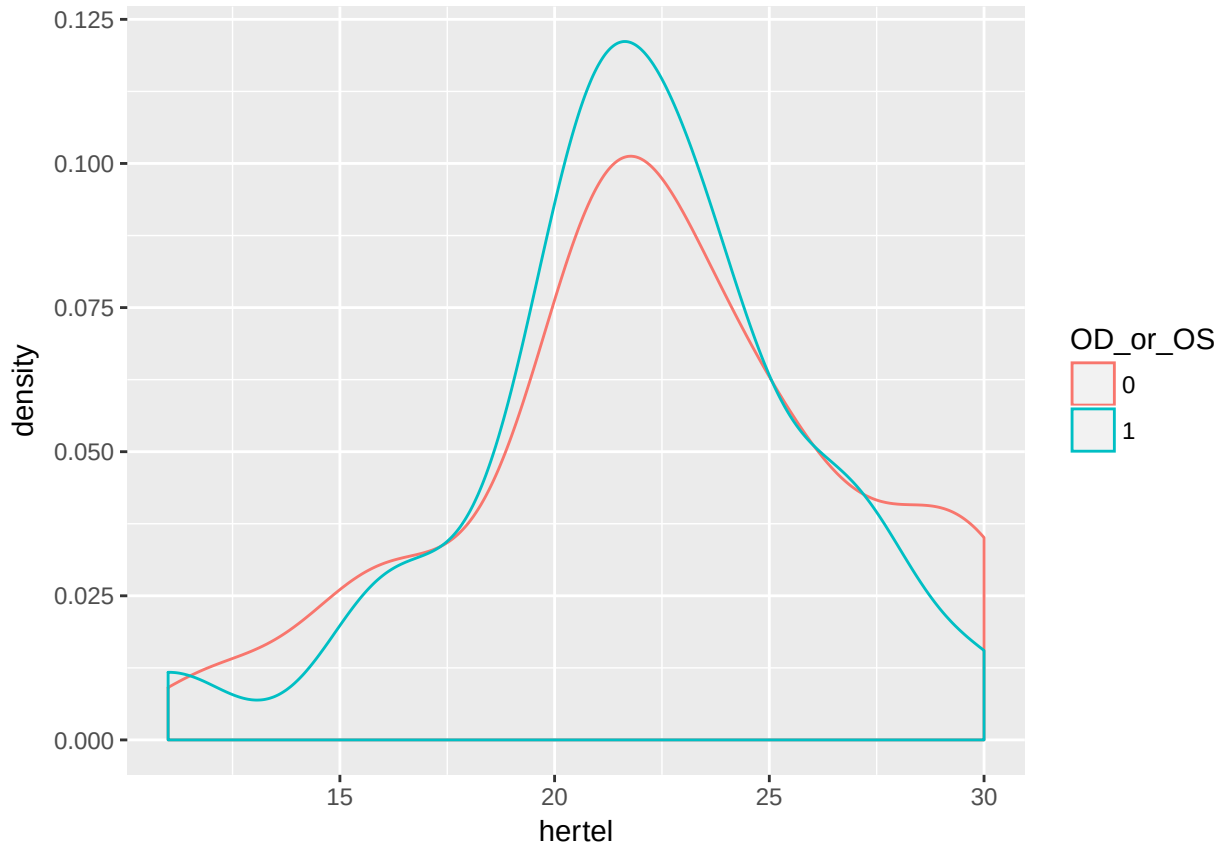

```
# fat volume
ggplot(tedv_exp, aes(x=fat_volume, colour= OD_or_OS)) + geom_density(alpha= 0.1)
```




```
#Muscle volume:
ggplot(tedv_exp, aes(x=muscle_volume, colour= OD_or_OS)) + geom_density(alpha= 0.1)
```

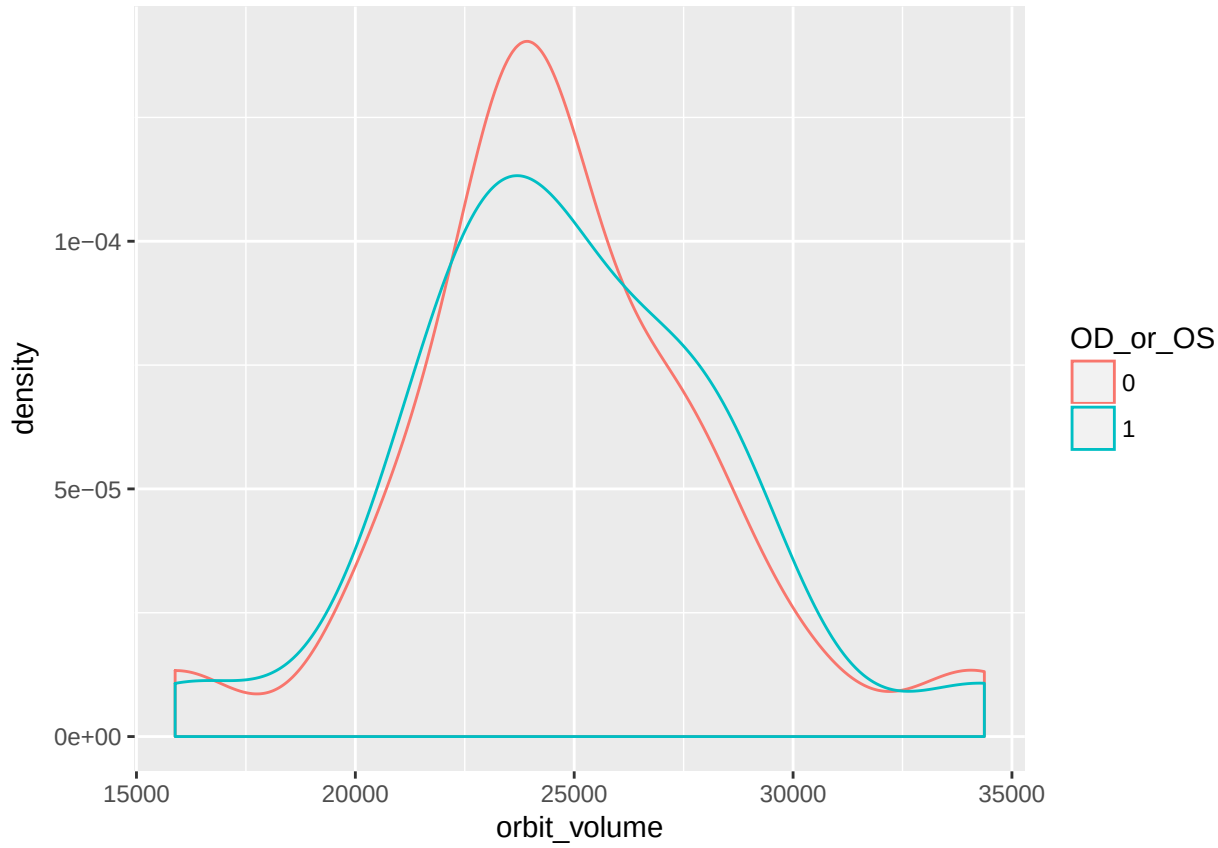



```
#Hertel
ggplot(tedv_exp, aes(x=hertel, colour= OD_or_OS)) + geom_density(alpha= 0.2)
```



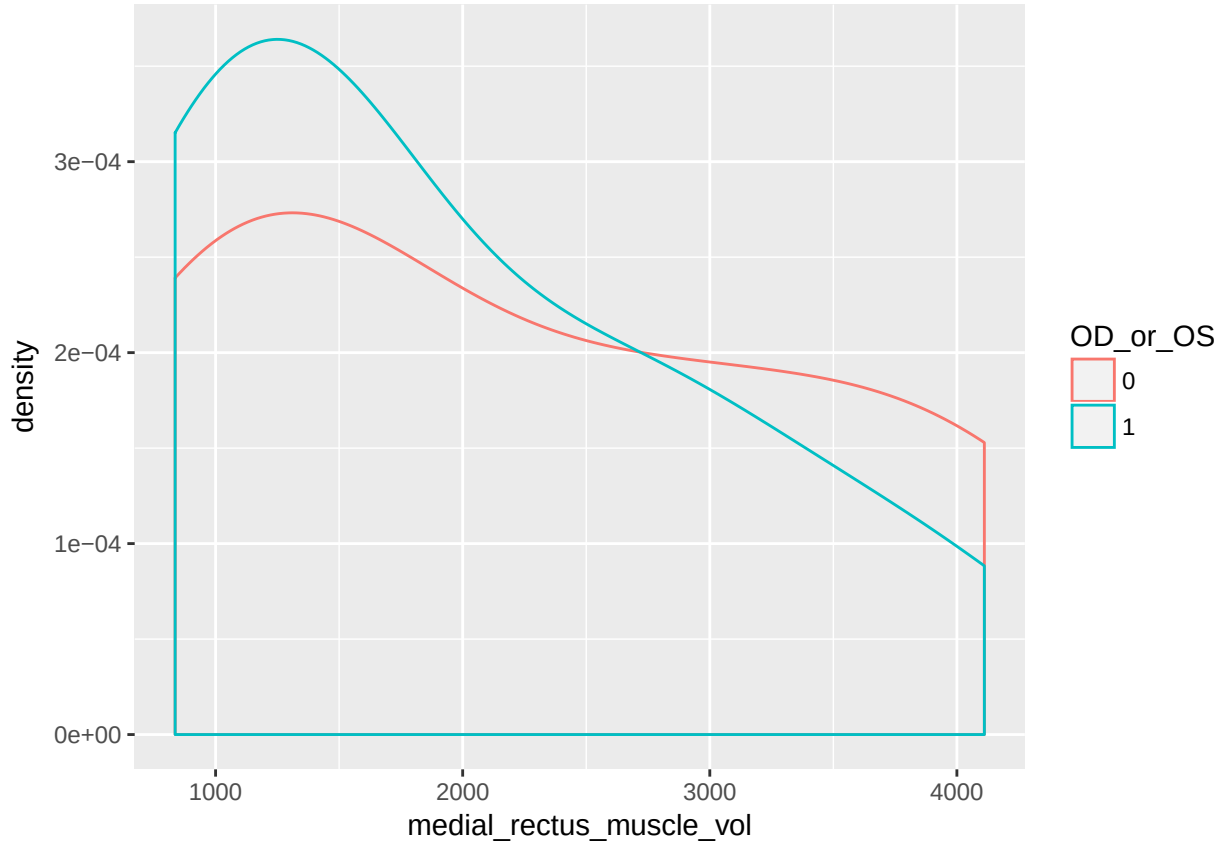

```
#Orbit volume:
ggplot(tedv_exp, aes(x=orbit_volume, colour= OD_or_OS)) + geom_density(alpha= 0.2)
```

```
## Warning: Removed 4 rows containing non-finite values (stat_density).
```




```
#Medial Rectus Volume: too few obsevations
ggplot(tedv_exp, aes(x=medial_rectus_muscle_vol, colour= OD_or_OS)) + geom_density(alpha= 0.2)
```

```
## Warning: Removed 32 rows containing non-finite values (stat_density).
```




```
# Checking correlations between left and right eye:
# Using pearson coefficients for numerical and chiquared for categorical

#Lagopthalmos- seems to be independent for two eyes in experiment
cor.test(subset(tedv_exp$lagophthalmos, tedv_exp$OD_or_OS ==1), subset(tedv_exp$lagophthalmos, tedv_exp
```

```
##
##  Pearson's product-moment correlation
##
## data:  subset(tedv_exp$lagophthalmos, tedv_exp$OD_or_OS == 1) and subset(tedv_exp$lagophthalmos, ted
## t = 1.8197, df = 18, p-value = 0.08548
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.05855501  0.71242947
## sample estimates:
##       cor
## 0.3941797
```

```
#Hertel- seems to be independent for two eyes in experiment
cor.test(subset(tedv_exp$hertel, tedv_exp$OD_or_OS ==1), subset(tedv_exp$hertel, tedv_exp$OD_or_OS==0),
```

```
##
##  Pearson's product-moment correlation
##
## data:  subset(tedv_exp$hertel, tedv_exp$OD_or_OS == 1) and subset(tedv_exp$hertel, tedv_exp$OD_or_OS
## t = 8.1366, df = 22, p-value = 4.452e-08
## alternative hypothesis: true correlation is not equal to 0
```

```
## 95 percent confidence interval:
##  0.7116876 0.9409178
## sample estimates:
##       cor
## 0.8663591
```

```
# Fat volume:
cor.test(subset(tedv_exp$fat_volume, tedv_exp$OD_or_OS ==1), subset(tedv_exp$fat_volume, tedv_exp$OD_or
```

```
##
##  Pearson's product-moment correlation
##
## data:  subset(tedv_exp$fat_volume, tedv_exp$OD_or_OS == 1) and subset(tedv_exp$fat_volume, tedv_exp$O
## t = 10.436, df = 22, p-value = 5.519e-10
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.8048635 0.9616707
## sample estimates:
##       cor
## 0.9121153
```

```
#Muscle volume- seems to be independent for two eyes in experiment
cor.test(subset(tedv_exp$muscle_volume, tedv_exp$OD_or_OS ==1), subset(tedv_exp$muscle_volume, tedv_exp
```

```
##
##  Pearson's product-moment correlation
##
## data:  subset(tedv_exp$muscle_volume, tedv_exp$OD_or_OS == 1) and subset(tedv_exp$muscle_volume, tedv
## t = 6.7908, df = 22, p-value = 8.003e-07
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.6277859 0.9206312
## sample estimates:
##       cor
## 0.8228089
```

```
#Orbital: seems to be independent for two eyes in experiment
cor.test(subset(tedv_exp$orbit_volume, tedv_exp$OD_or_OS ==1), subset(tedv_exp$orbit_volume, tedv_exp$O
```

```
##
##  Pearson's product-moment correlation
##
## data:  subset(tedv_exp$orbit_volume, tedv_exp$OD_or_OS == 1) and subset(tedv_exp$orbit_volume, tedv_e
## t = 27.792, df = 20, p-value < 2.2e-16
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.9690698 0.9948131
## sample estimates:
##       cor
## 0.9872993
```

```
# Medial Rectus: Too few observations: But seems significant at 90%
cor.test(subset(tedv_exp$medial_rectus_muscle_vol, tedv_exp$OD_or_OS ==1), subset(tedv_exp$medial_rectus
```

```
##
##  Pearson's product-moment correlation
##
```

```
## data:  subset(tedv_exp$medial_rectus_muscle_vol, tedv_exp$OD_or_OS ==  and subset(tedv_exp$medial_re
## t = 2.2516, df = 6, p-value = 0.0653
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.05339505  0.93535895
## sample estimates:
##      cor
## 0.676741
```

```
# Next step would be to fit models separately for both left and right and see how they compare. ( To do
```

Conclusions: Seem indepedent as per pearson's coefficient, but look related in the plots (ask prof)

Control vs Experimental (Kitu)

```
# split dataset into control and experimental
TEDV_control <- TEDV[control == 1, ]
TEDV_experimental <- TEDV[control == 0, ]

# summary stats
summary(TEDV_control)
```

```
##  Time.of.Image...Date.of.visit      Age          CAS.score     OSDI.score
##  Min.   : NA                   Min.   :18.0   Min.   : NA   Min.   : NA
##  1st Qu.: NA                   1st Qu.:30.0   1st Qu.: NA   1st Qu.: NA
##  Median : NA                   Median :42.0   Median : NA   Median : NA
##  Mean   :NaN                   Mean   :44.9   Mean   :NaN   Mean   :NaN
##  3rd Qu.: NA                   3rd Qu.:58.0   3rd Qu.: NA   3rd Qu.: NA
##  Max.   : NA                   Max.   :91.0   Max.   : NA   Max.   : NA
##  NA's   :21                                   NA's   :21    NA's   :21
##  baseline.visit.date time.from.onset Strabismus.0.No.1.yes    control
##  Min.   : NA         Min.   : NA     Min.   : NA           Min.   :1
##  1st Qu.: NA         1st Qu.: NA     1st Qu.: NA           1st Qu.:1
##  Median : NA         Median : NA     Median : NA           Median :1
##  Mean   :NaN         Mean   :NaN     Mean   :NaN           Mean   :1
##  3rd Qu.: NA         3rd Qu.: NA     3rd Qu.: NA           3rd Qu.:1
##  Max.   : NA         Max.   : NA     Max.   : NA           Max.   :1
##  NA's   :21          NA's   :21      NA's   :21
##     OD_or_OS optic_neuropathy lagophthalmos     hertel      medial_bow
##  Min.   :1   Min.   :0        Min.   : NA   Min.   : NA   Min.   : NA
##  1st Qu.:1   1st Qu.:0        1st Qu.: NA   1st Qu.: NA   1st Qu.: NA
##  Median :1   Median :0        Median : NA   Median : NA   Median : NA
##  Mean   :1   Mean   :0        Mean   :NaN   Mean   :NaN   Mean   :NaN
##  3rd Qu.:1   3rd Qu.:0        3rd Qu.: NA   3rd Qu.: NA   3rd Qu.: NA
##  Max.   :1   Max.   :0        Max.   : NA   Max.   : NA   Max.   : NA
##                               NA's   :21    NA's   :21    NA's   :21
##  decompression   fat_volume    muscle_volume    orbit_volume
##  Min.   : NA   Min.   : 4257   Min.   : 5773   Min.   :18267
##  1st Qu.: NA   1st Qu.: 5337   1st Qu.: 7076   1st Qu.:19936
##  Median : NA   Median : 6423   Median : 7504   Median :22338
##  Mean   :NaN   Mean   : 6700   Mean   : 7898   Mean   :22160
##  3rd Qu.: NA   3rd Qu.: 7635   3rd Qu.: 8081   3rd Qu.:23303
##  Max.   : NA   Max.   :10611   Max.   :12403   Max.   :26997
```

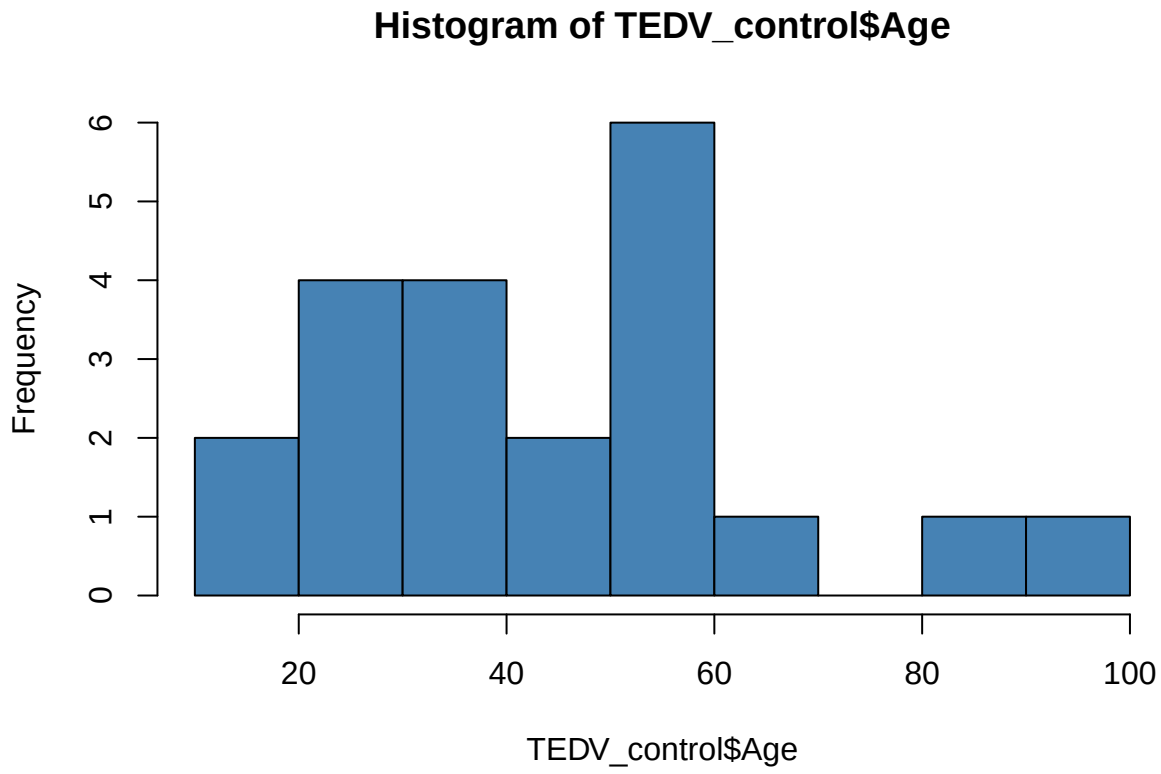
```
##  NA's   :21    NA's   :2       NA's   :2       NA's   :2
##      FV.OV           MV.OV       medial_rectus_muscle_vol fat_muscle_ratio
##  Min.   :18.70   Min.   :26.64   Min.   : 649.8           Min.   :0.5064
##  1st Qu.:25.38   1st Qu.:30.80   1st Qu.: 660.2           1st Qu.:0.6458
##  Median :30.85   Median :34.40   Median : 831.9           Median :0.8068
##  Mean   :30.22   Mean   :35.93   Mean   : 837.3           Mean   :0.8762
##  3rd Qu.:33.24   3rd Qu.:38.77   3rd Qu.: 896.6           3rd Qu.:1.0845
##  Max.   :43.65   Max.   :58.66   Max.   :1148.0           Max.   :1.4264
##  NA's   :2       NA's   :2       NA's   :16               NA's   :2
```

```
summary(TEDV_experimental)
```

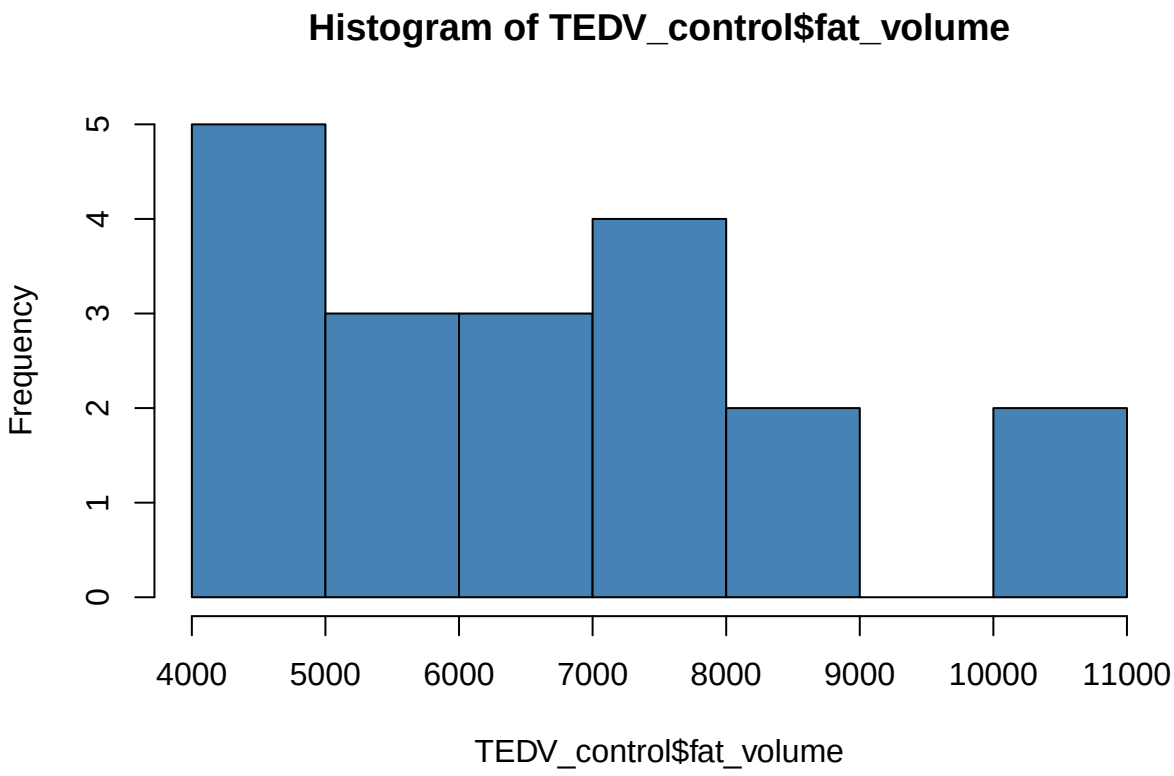
```
##  Time.of.Image...Date.of.visit      Age          CAS.score
##  Min.   :-592.00               Min.   :22.79   Min.   :0.000
##  1st Qu.: -18.25               1st Qu.:42.68   1st Qu.:1.000
##  Median :   6.00               Median :53.46   Median :2.500
##  Mean   : -27.75               Mean   :52.81   Mean   :2.667
##  3rd Qu.:  32.25               3rd Qu.:58.19   3rd Qu.:4.250
##  Max.   : 117.00               Max.   :87.20   Max.   :6.000
##  NA's   :8
##    OSDI.score      baseline.visit.date time.from.onset
##  Min.   :  4.167   Min.   :41740       Min.   :  71
##  1st Qu.: 22.396   1st Qu.:42111       1st Qu.: 235
##  Median : 52.083   Median :42398       Median : 441
##  Mean   : 48.021   Mean   :42259       Mean   :1075
##  3rd Qu.: 70.833   3rd Qu.:42447       3rd Qu.:1268
##  Max.   :100.000   Max.   :42558       Max.   :5801
##  NA's   :8         NA's   :6           NA's   :8
##  Strabismus.0.No.1.yes    control     OD_or_OS   optic_neuropathy
##  Min.   :0.0000        Min.   :0   Min.   :0.0   Min.   :0.0000
##  1st Qu.:0.0000        1st Qu.:0   1st Qu.:0.0   1st Qu.:0.0000
##  Median :1.0000        Median :0   Median :0.5   Median :0.0000
##  Mean   :0.5833        Mean   :0   Mean   :0.5   Mean   :0.1875
##  3rd Qu.:1.0000        3rd Qu.:0   3rd Qu.:1.0   3rd Qu.:0.0000
##  Max.   :1.0000        Max.   :0   Max.   :1.0   Max.   :1.0000
##
##  lagophthalmos        hertel        medial_bow   decompression
##  Min.   :0.0000   Min.   :11.00   Min.   :0.00   Min.   :0.00
##  1st Qu.:0.0000   1st Qu.:20.00   1st Qu.:0.00   1st Qu.:0.00
##  Median :0.0000   Median :22.00   Median :0.00   Median :0.00
##  Mean   :0.5737   Mean   :22.10   Mean   :0.25   Mean   :0.45
##  3rd Qu.:1.0000   3rd Qu.:24.25   3rd Qu.:0.25   3rd Qu.:1.00
##  Max.   :2.0000   Max.   :30.00   Max.   :1.00   Max.   :1.00
##  NA's   :8                        NA's   :8      NA's   :8
##    fat_volume    muscle_volume    orbit_volume       FV.OV
##  Min.   : 2021   Min.   : 5041   Min.   :15883   Min.   : 8.077
##  1st Qu.: 5076   1st Qu.: 9572   1st Qu.:22949   1st Qu.:22.222
##  Median : 8434   Median :11442   Median :24136   Median :32.885
##  Mean   : 8366   Mean   :11544   Mean   :24763   Mean   :32.857
##  3rd Qu.:10713   3rd Qu.:13255   3rd Qu.:27256   3rd Qu.:39.929
##  Max.   :19101   Max.   :18649   Max.   :34370   Max.   :55.576
##                                  NA's   :4       NA's   :6
##      MV.OV       medial_rectus_muscle_vol fat_muscle_ratio
##  Min.   :20.41   Min.   : 836.3           Min.   :0.1921
##  1st Qu.:42.14   1st Qu.:1103.9           1st Qu.:0.3950
```

```
##  Median :47.80   Median :1531.9          Median :0.6679
##  Mean   :48.36   Mean   :2081.2          Mean   :0.7960
##  3rd Qu.:54.28   3rd Qu.:2823.7          3rd Qu.:1.1168
##  Max.   :74.68   Max.   :4111.2          Max.   :2.4685
##  NA's   :6       NA's   :32
```

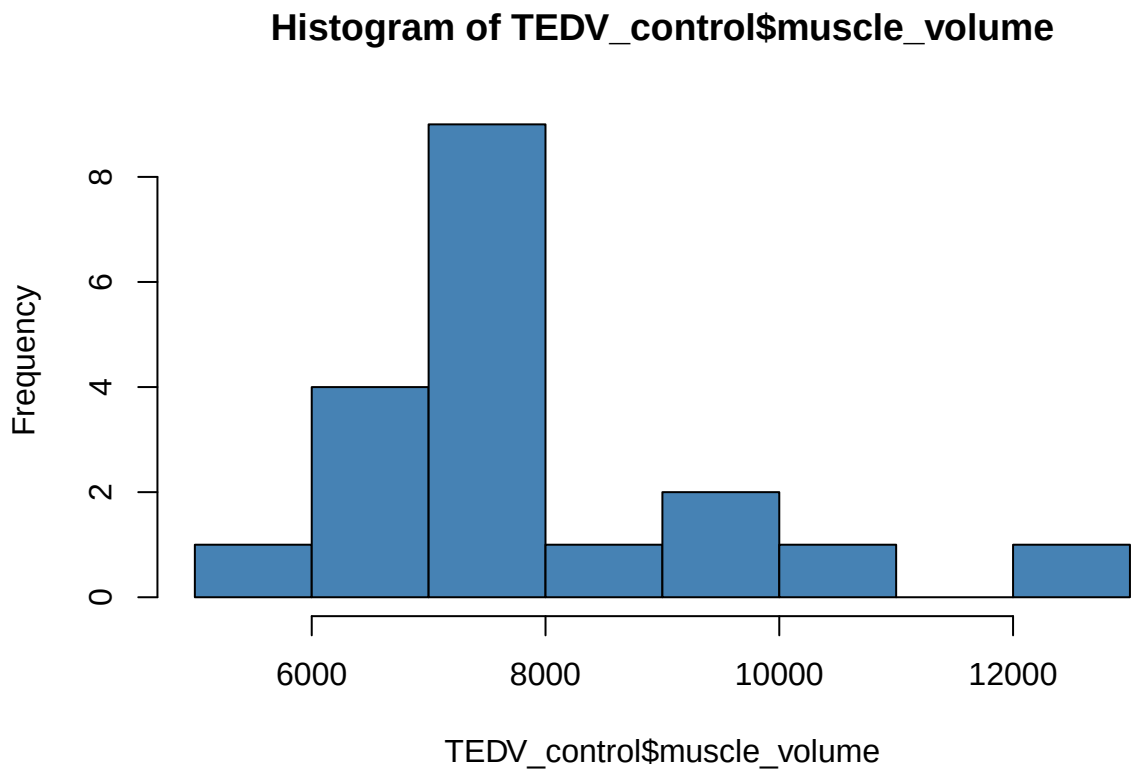
```r
# histograms of controls
hist(TEDV_control$Age, col = "steelblue")
```



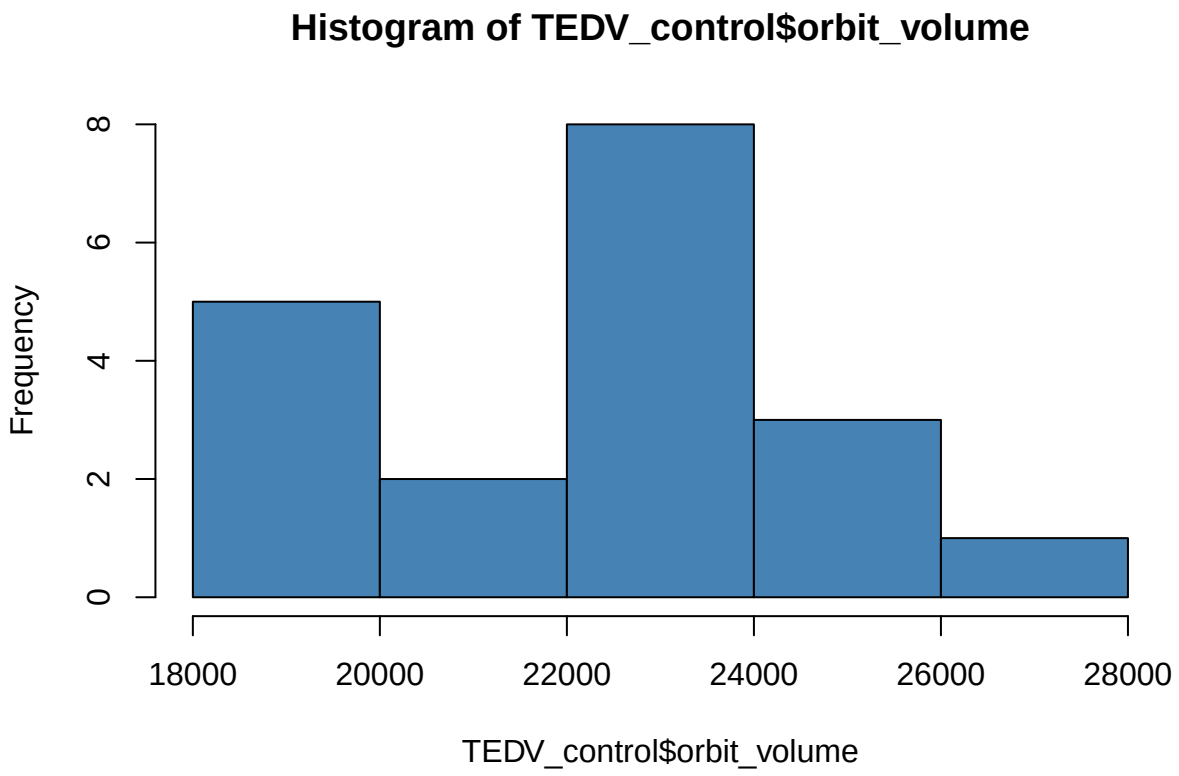

```r
hist(TEDV_control$fat_volume, col = "steelblue")
```



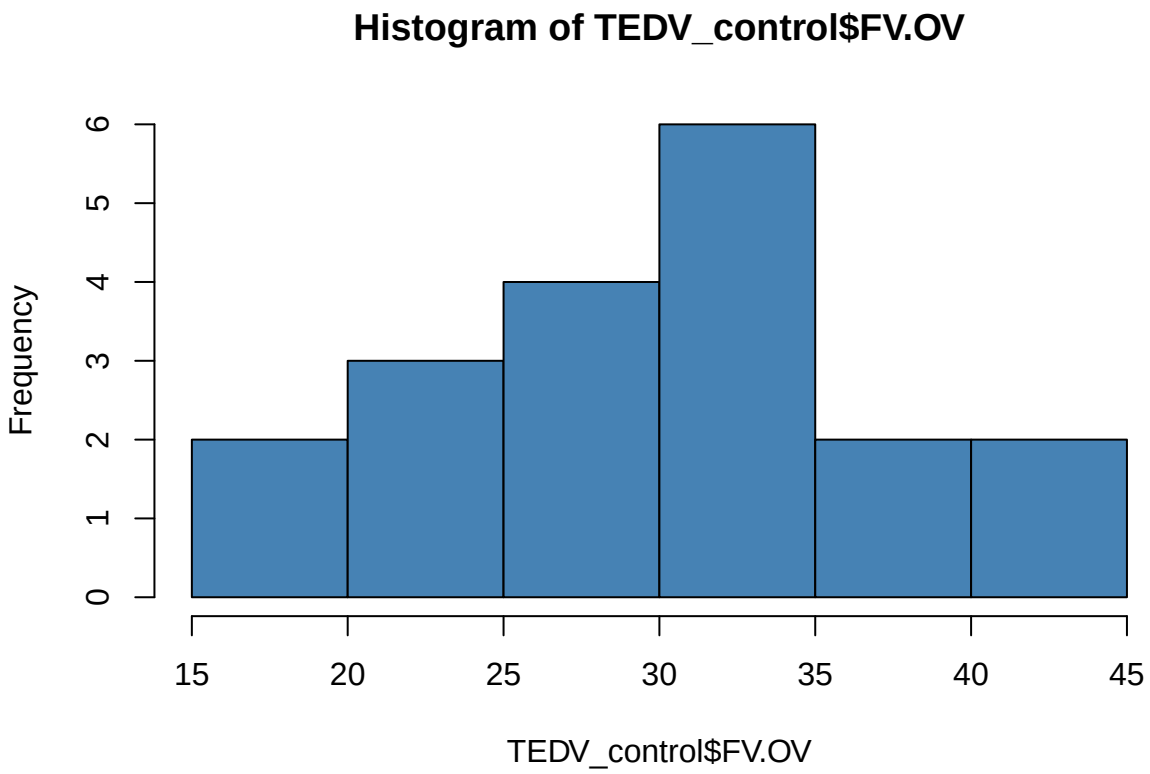

```r
hist(TEDV_control$muscle_volume, col = "steelblue")
```



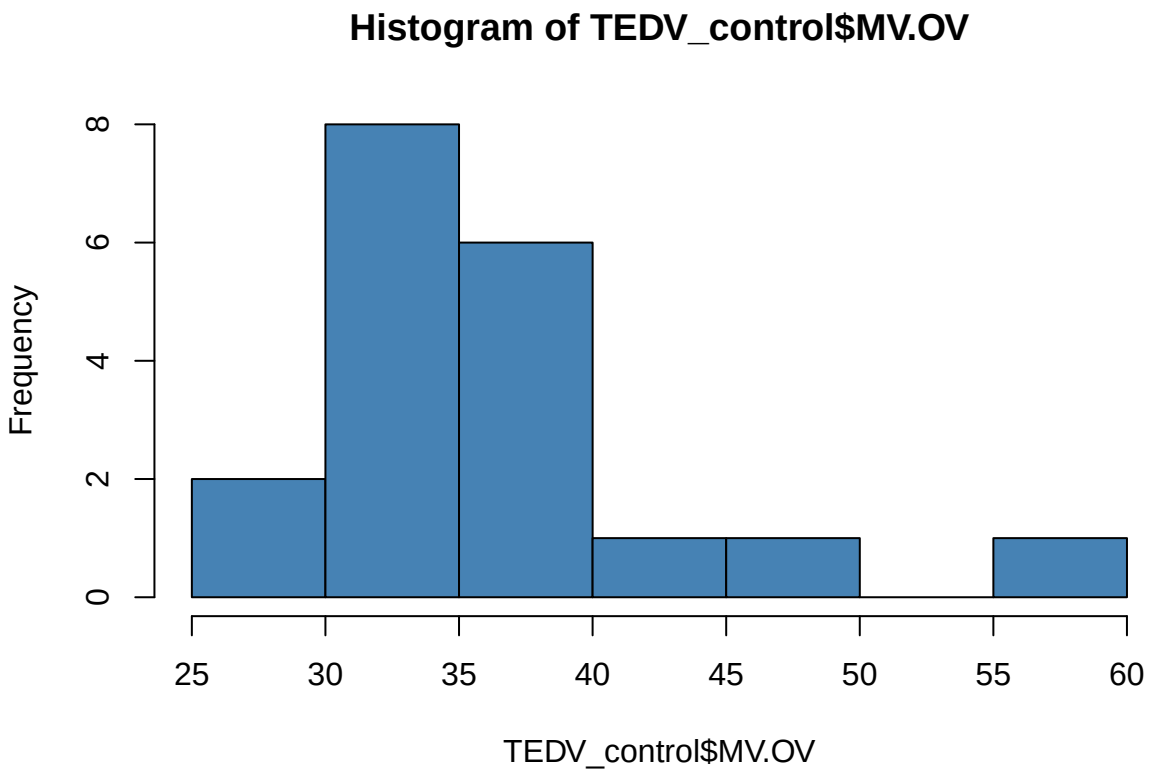

```r
hist(TEDV_control$orbit_volume, col = "steelblue")
```



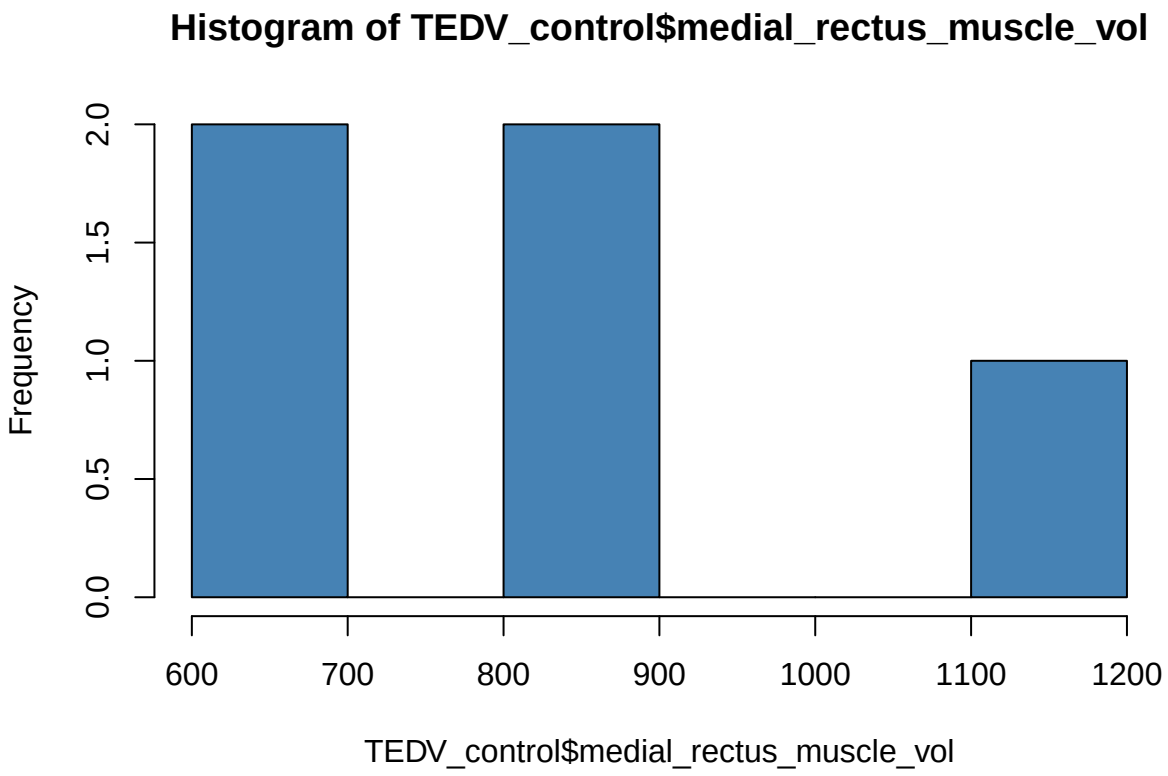

```
hist(TEDV_control$FV.OV, col = "steelblue")
```



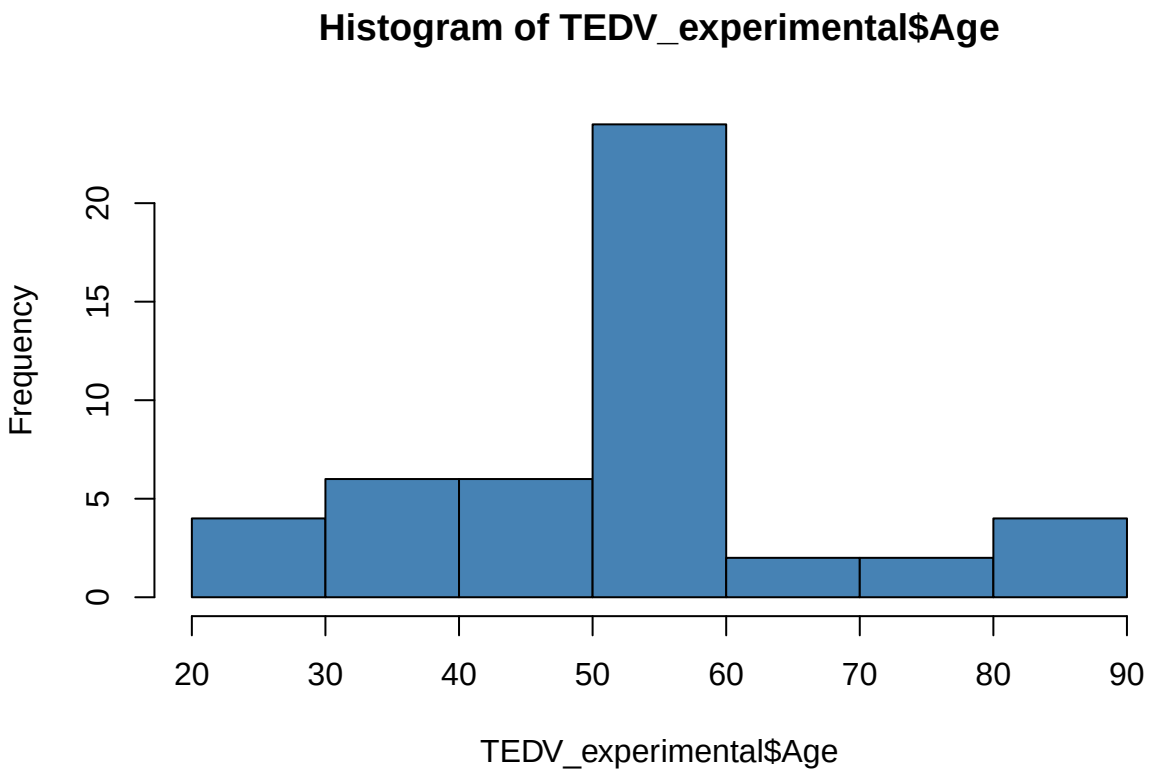

```r
hist(TEDV_control$MV.OV, col = "steelblue")
```



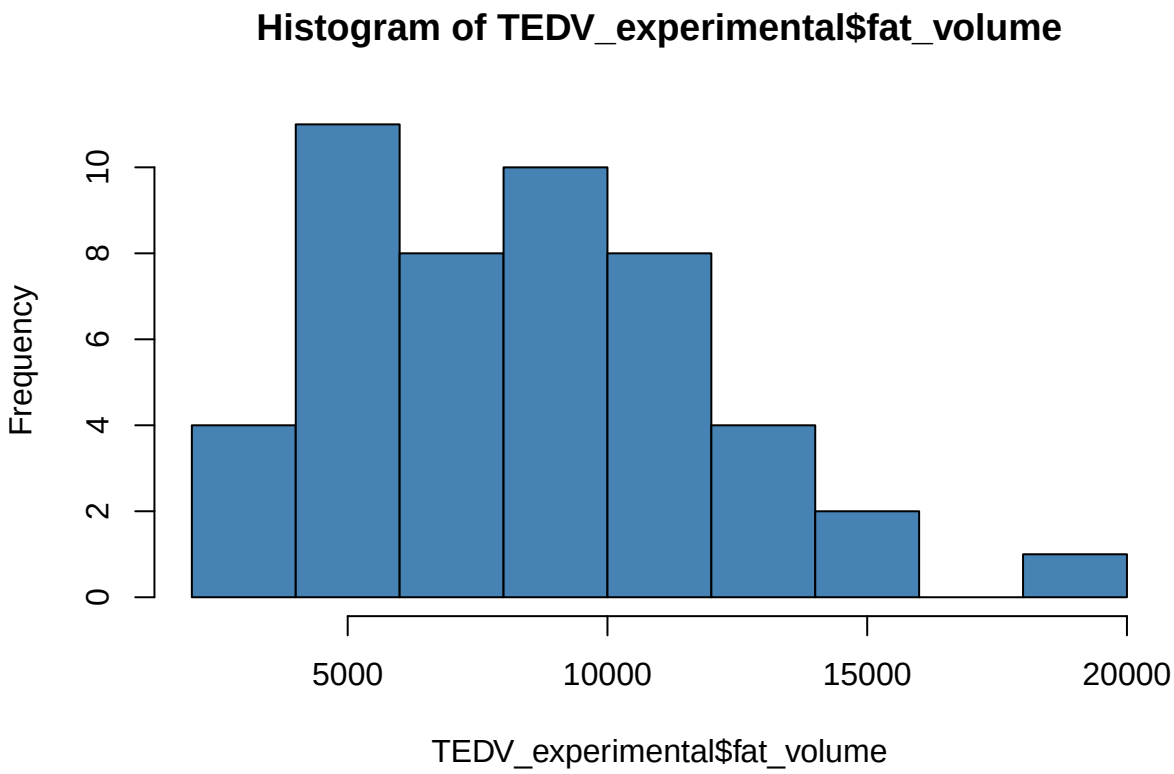

```
hist(TEDV_control$medial_rectus_muscle_vol, col = "steelblue")
```



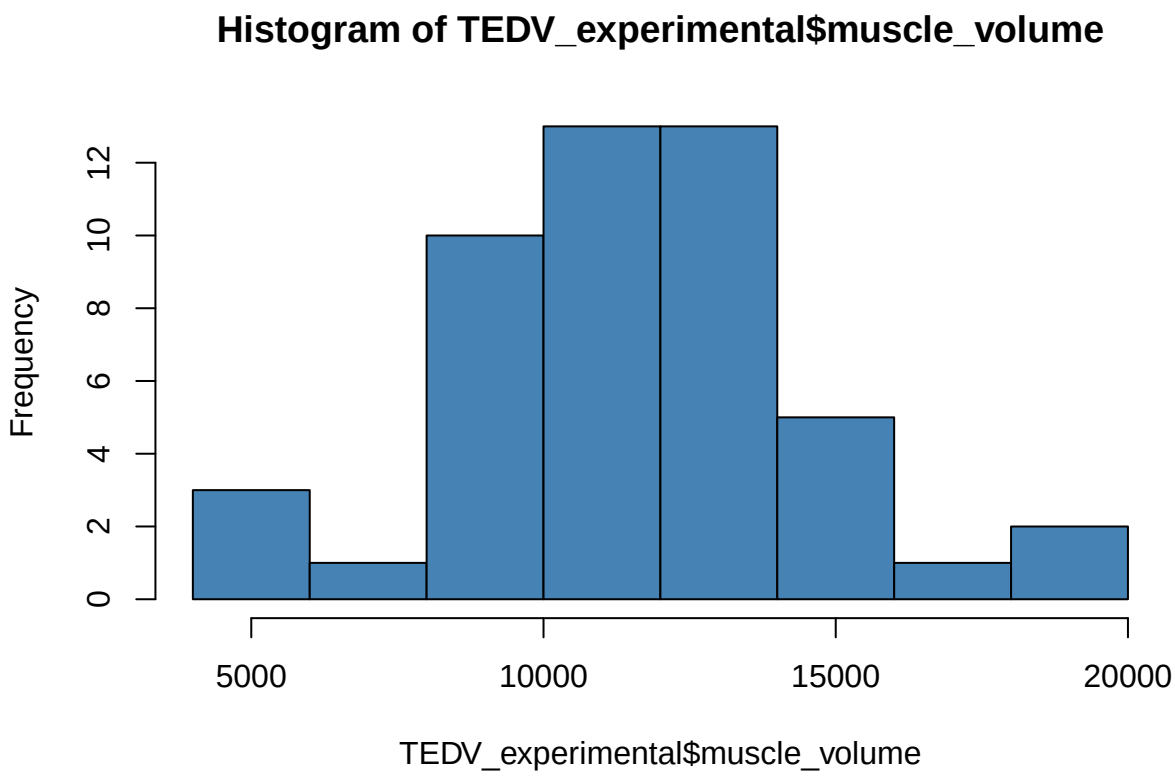

```r
# histograms of experimentals
hist(TEDV_experimental$Age, col = "steelblue")
```



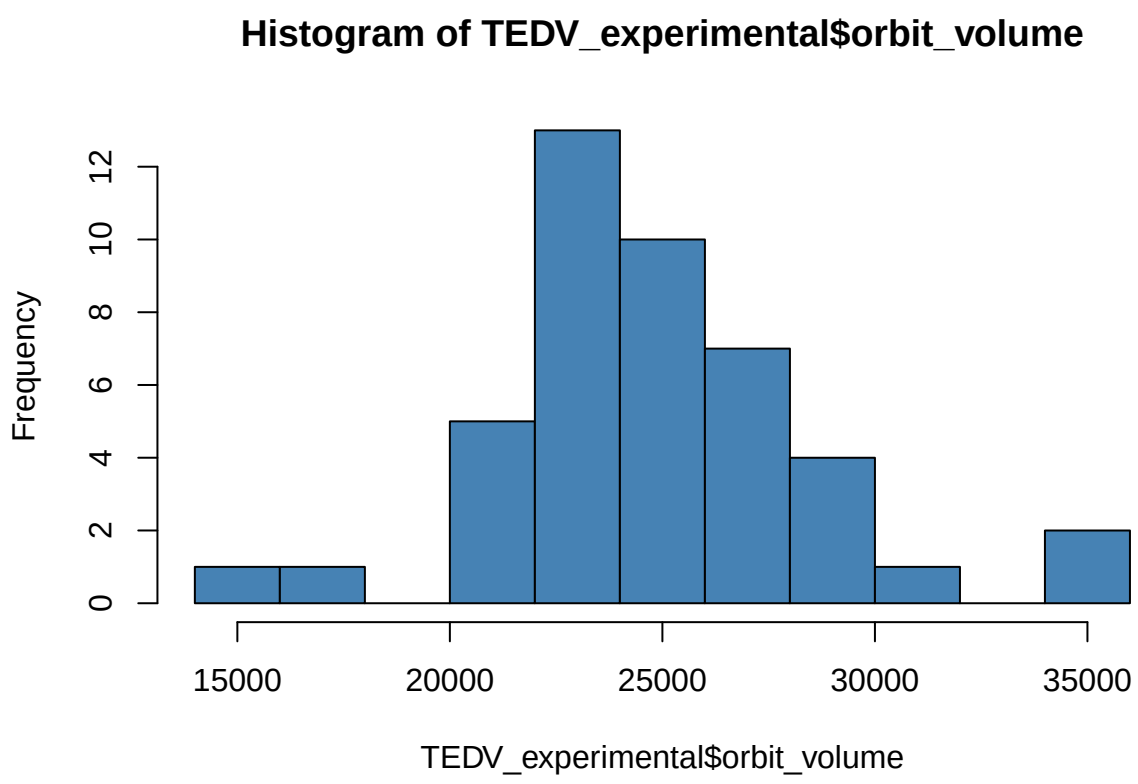

```
hist(TEDV_experimental$fat_volume, col = "steelblue")
```



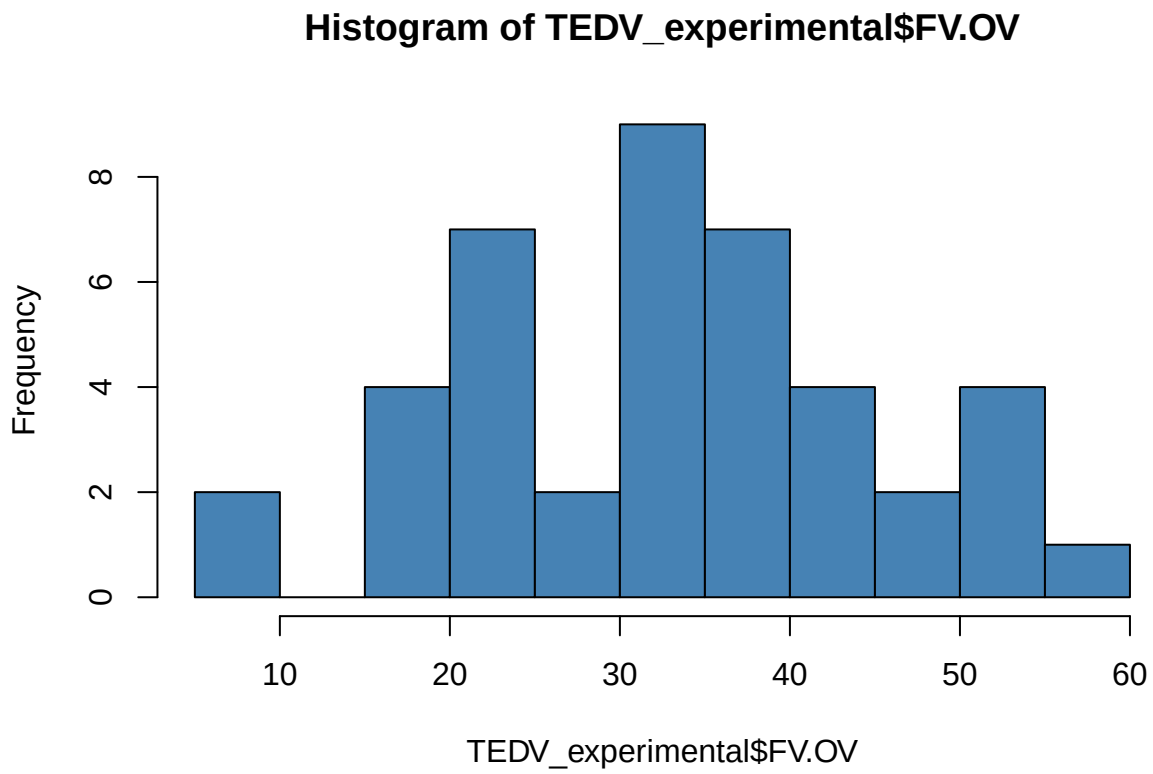

```
hist(TEDV_experimental$muscle_volume, col = "steelblue")
```



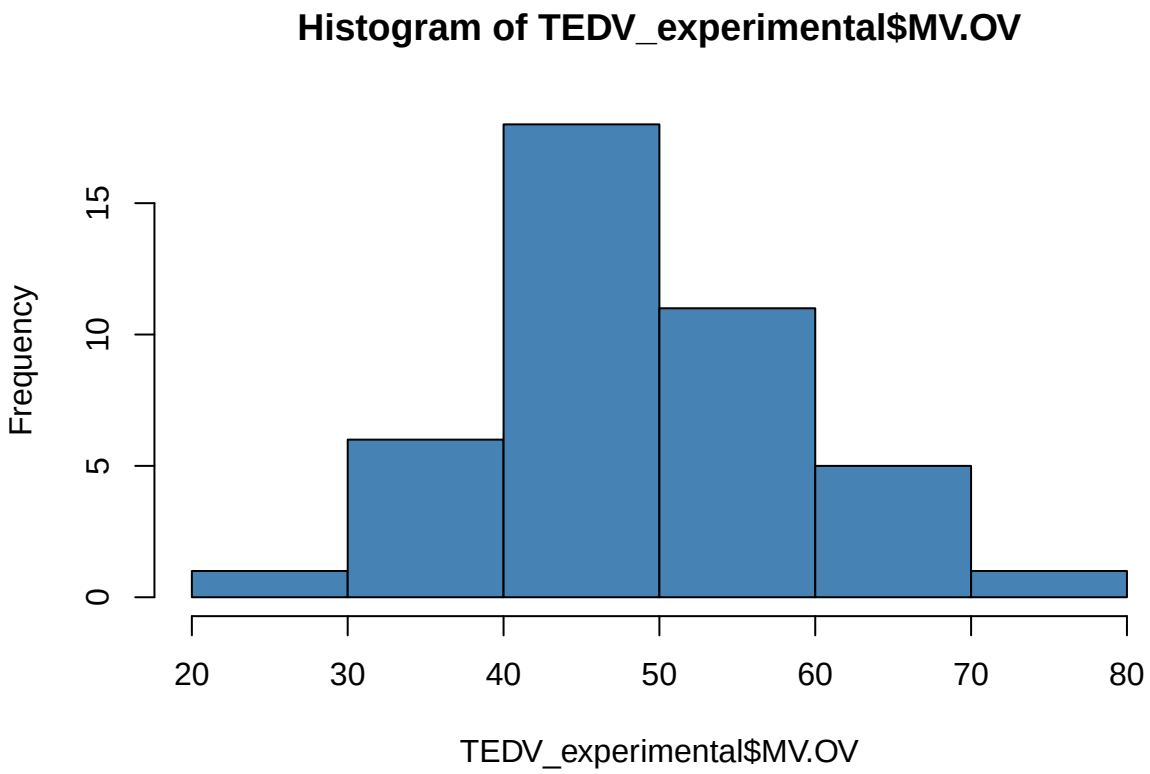

```
hist(TEDV_experimental$orbit_volume, col = "steelblue")
```



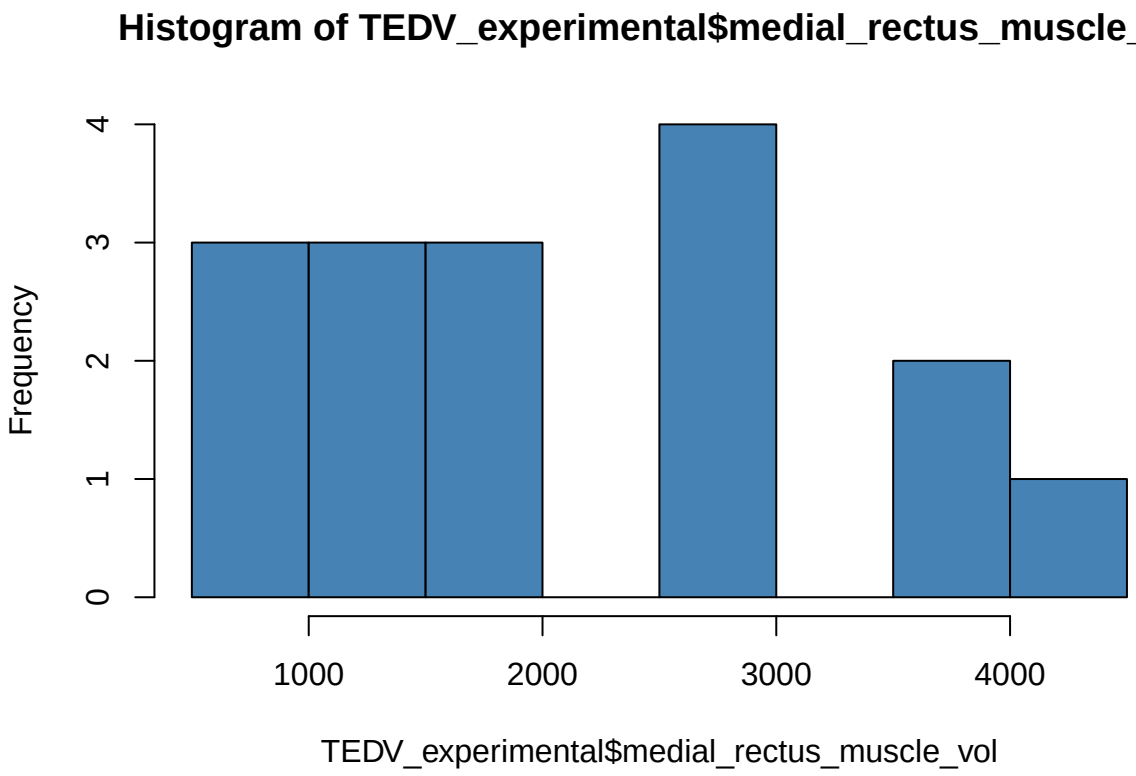

```
hist(TEDV_experimental$FV.OV, col = "steelblue")
```




```
hist(TEDV_experimental$MV.OV, col = "steelblue")
```




```
hist(TEDV_experimental$medial_rectus_muscle_vol, col = "steelblue")
```




```
# t-tests on all vars
t.test(TEDV_control$Age, TEDV_experimental$Age) # not significant: 0.1111
```

```
##
##  Welch Two Sample t-test
##
## data:  TEDV_control$Age and TEDV_experimental$Age
## t = -1.6403, df = 30.87, p-value = 0.1111
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -17.727365   1.924788
## sample estimates:
## mean of x mean of y
##  44.90476  52.80605
```

```
t.test(TEDV_control$fat_volume, TEDV_experimental$fat_volume) # signifcant: 0.01603
```

```
##
##  Welch Two Sample t-test
##
## data:  TEDV_control$fat_volume and TEDV_experimental$fat_volume
## t = -2.4757, df = 62.215, p-value = 0.01603
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -3010.9356  -320.9043
## sample estimates:
## mean of x mean of y
```

```
##  6699.896  8365.816
```

```
t.test(TEDV_control$muscle_volume, TEDV_experimental$muscle_volume) # significant: 1.894*10^-8
```

```
##
##  Welch Two Sample t-test
##
## data:  TEDV_control$muscle_volume and TEDV_experimental$muscle_volume
## t = -6.4901, df = 59.542, p-value = 1.894e-08
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -4770.161 -2522.242
## sample estimates:
## mean of x mean of y
##  7897.825 11544.026
```

```
t.test(TEDV_control$orbit_volume, TEDV_experimental$orbit_volume) # significant: 0.00222
```

```
##
##  Welch Two Sample t-test
##
## data:  TEDV_control$orbit_volume and TEDV_experimental$orbit_volume
## t = -3.2324, df = 48.083, p-value = 0.00222
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -4222.2306  -983.9619
## sample estimates:
## mean of x mean of y
##  22160.14  24763.24
```

```
t.test(TEDV_control$FV.OV, TEDV_experimental$FV.OV) # not significant: 0.29
```

```
##
##  Welch Two Sample t-test
##
## data:  TEDV_control$FV.OV and TEDV_experimental$FV.OV
## t = -1.0684, df = 55.431, p-value = 0.29
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -7.586280  2.309578
## sample estimates:
## mean of x mean of y
##  30.21913  32.85748
```

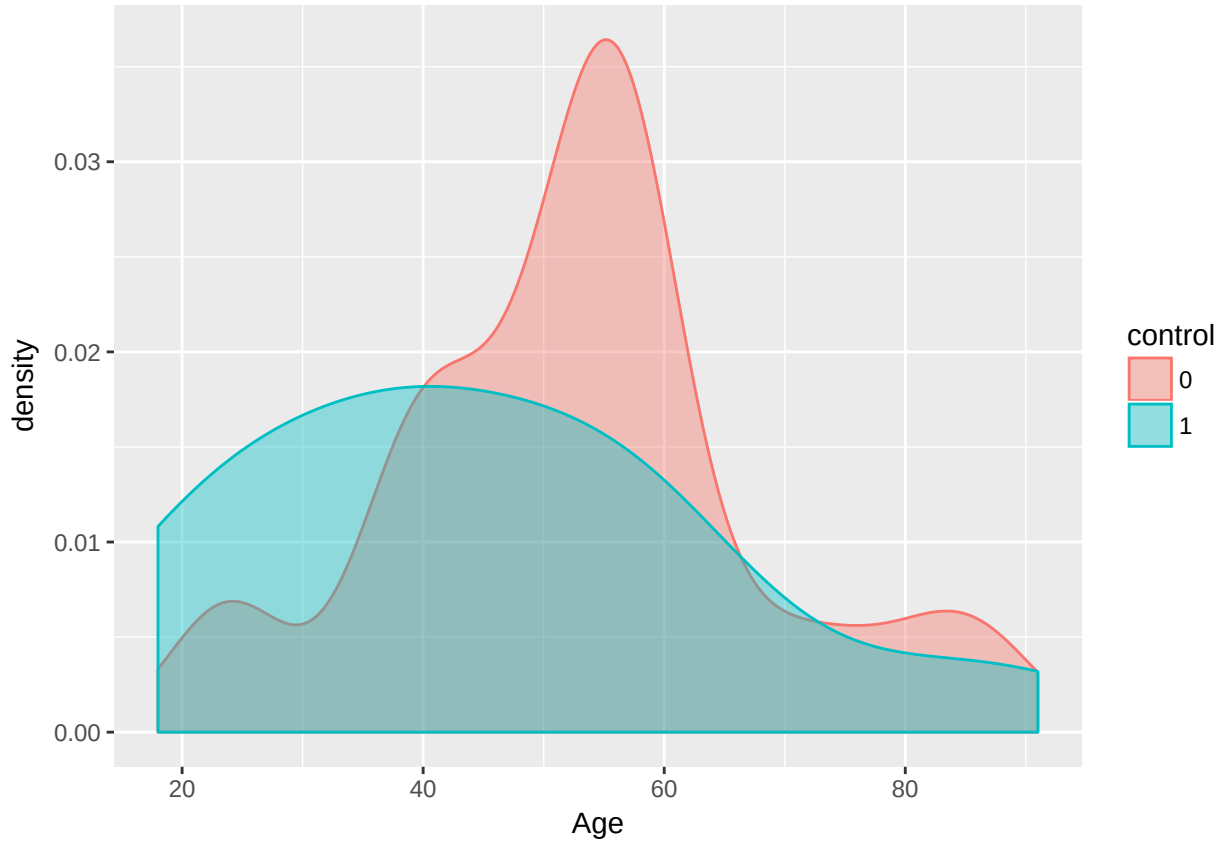
```
t.test(TEDV_control$MV.OV, TEDV_experimental$MV.OV) # significant: 3.939*10^-6
```

```
##
##  Welch Two Sample t-test
##
## data:  TEDV_control$MV.OV and TEDV_experimental$MV.OV
## t = -5.2212, df = 47.147, p-value = 3.939e-06
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -17.218475  -7.640837
## sample estimates:
## mean of x mean of y
##  35.93404  48.36370
```

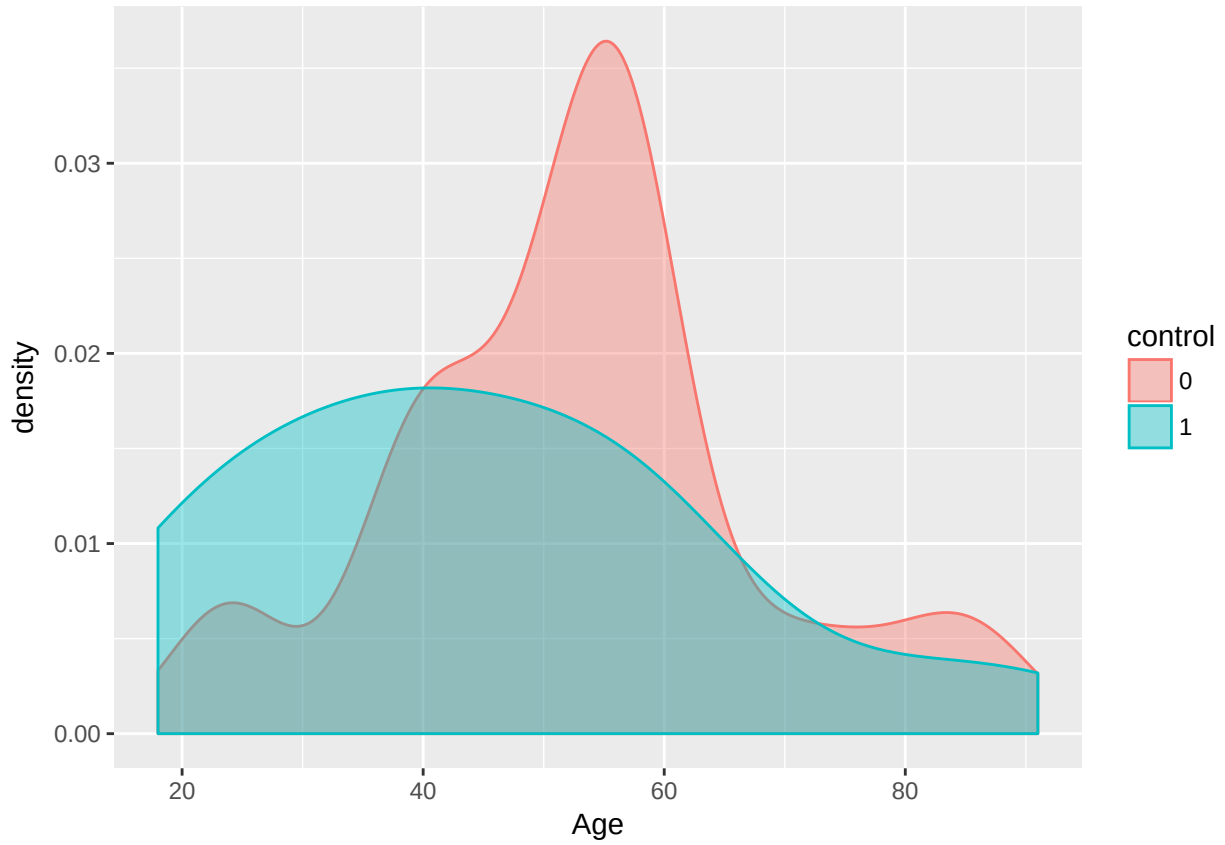
```r
t.test(TEDV_control$medial_rectus_muscle_vol, TEDV_experimental$medial_rectus_muscle_vol) # significant
```

```
##
##  Welch Two Sample t-test
##
## data:  TEDV_control$medial_rectus_muscle_vol and TEDV_experimental$medial_rectus_muscle_vol
## t = -4.1004, df = 17.485, p-value = 0.0007083
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -1882.5377  -605.1913
## sample estimates:
## mean of x mean of y
##   837.308  2081.173
```

```r
# plots comparing control with experimental
library(ggplot2)
TEDV$control <- as.factor(TEDV$control)
ggplot(TEDV, aes(x = Age, color = control, fill = control)) + geom_density(alpha = 0.4)
```

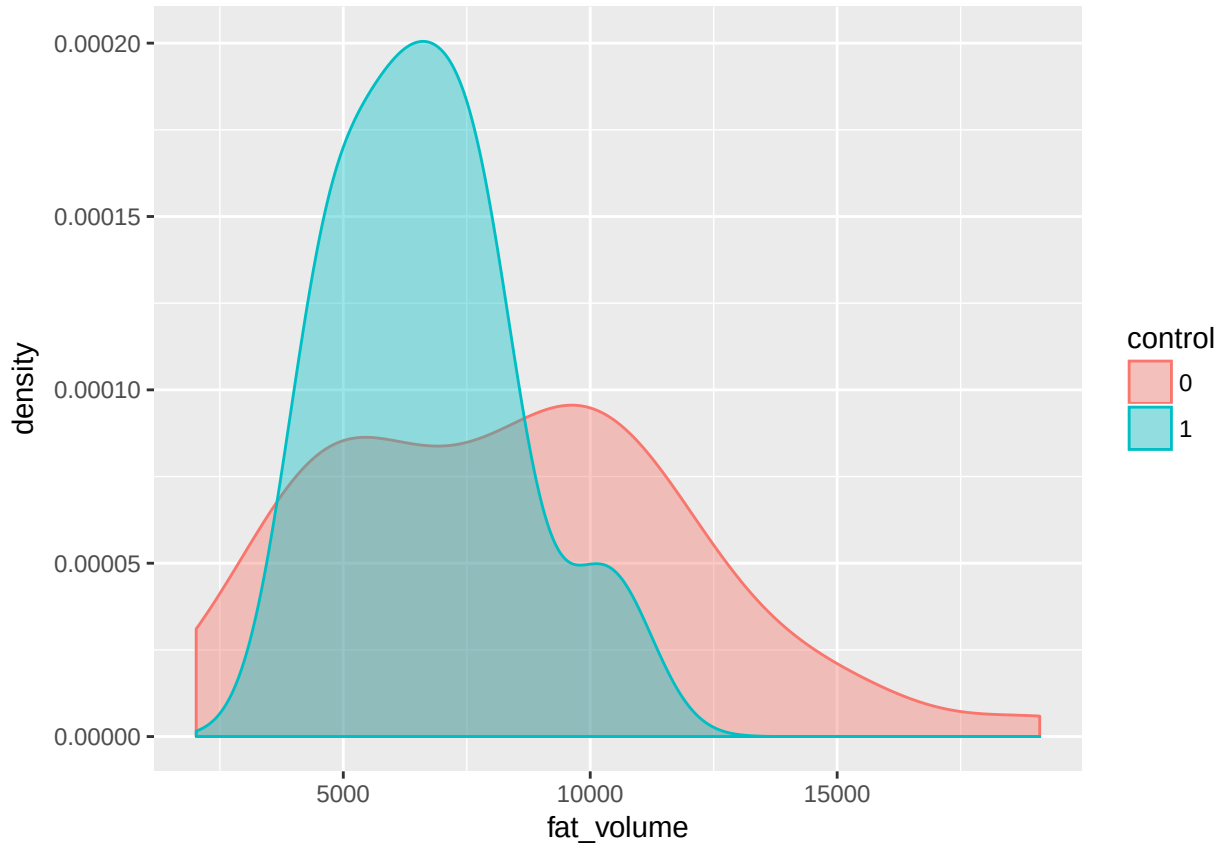



```r
  #geom_histogram(data = subset(TEDV, control == 1), fill = "red", alpha = 0.2) +
  #geom_histogram(data = subset(TEDV, control == 0), fill = "blue", alpha = 0.2)
ggplot(TEDV, aes(x = Age, color = control, fill = control)) + geom_density(alpha = 0.4)
```



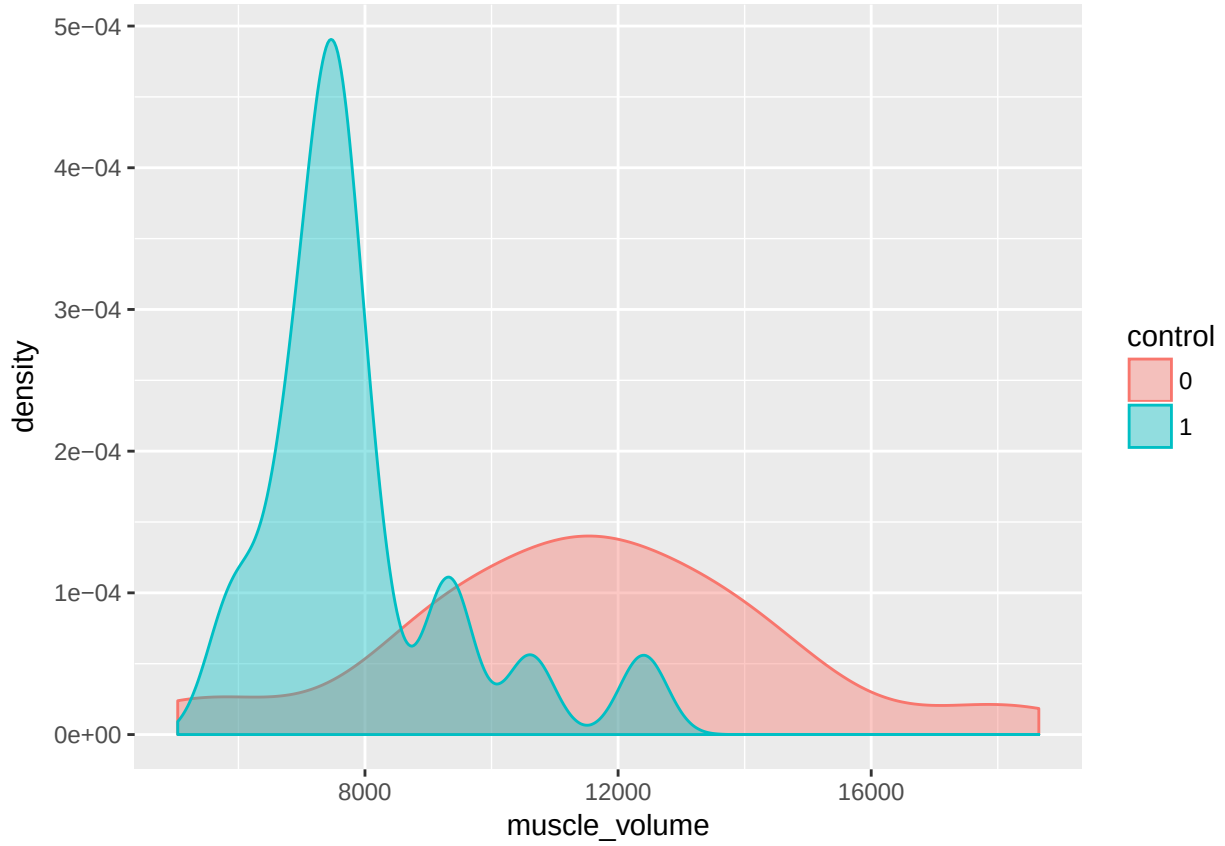

```
ggplot(TEDV, aes(x = fat_volume, color = control, fill = control)) + geom_density(alpha = 0.4)
```

```
## Warning: Removed 2 rows containing non-finite values (stat_density).
```



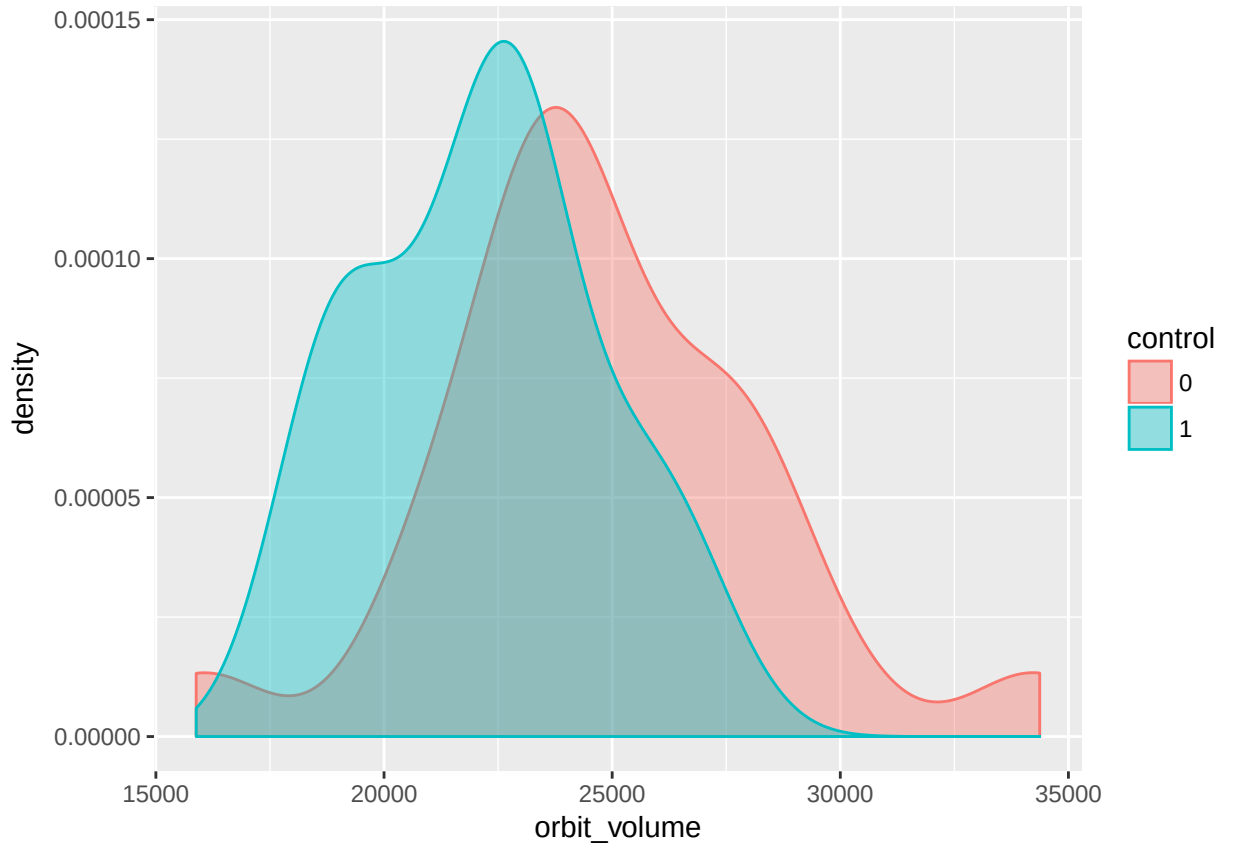

```
ggplot(TEDV, aes(x = muscle_volume, color = control, fill = control)) + geom_density(alpha = 0.4)
```

```
## Warning: Removed 2 rows containing non-finite values (stat_density).
```



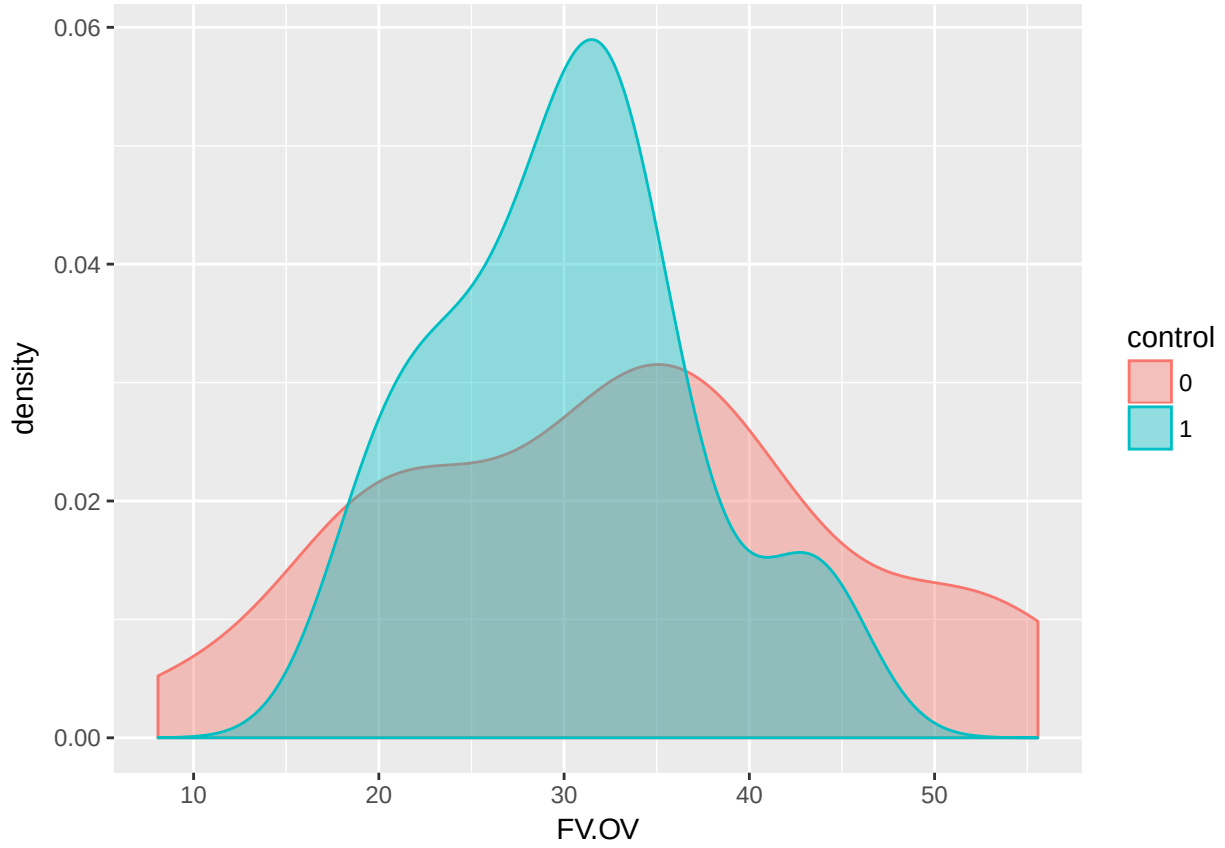

```
ggplot(TEDV, aes(x = orbit_volume, color = control, fill = control)) + geom_density(alpha = 0.4)
```

```
## Warning: Removed 6 rows containing non-finite values (stat_density).
```



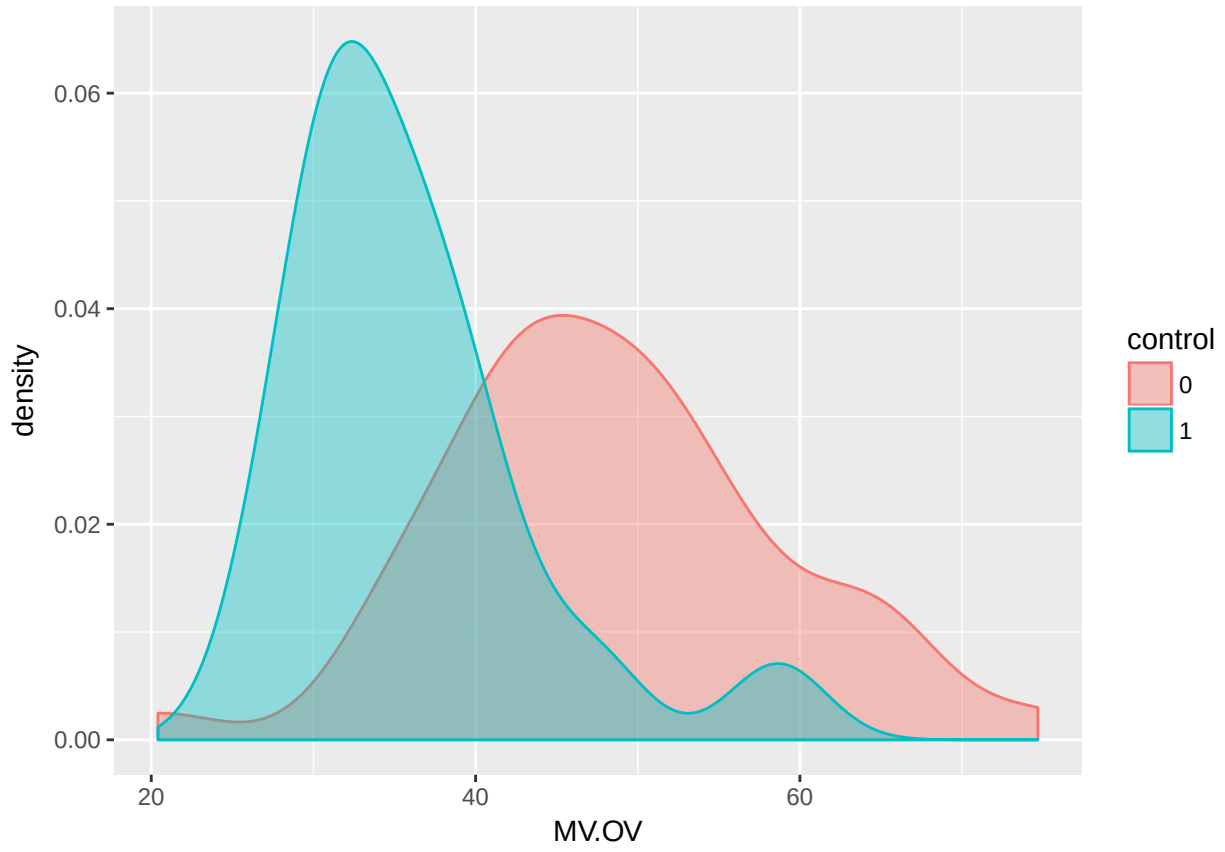

```
ggplot(TEDV, aes(x = FV.OV, color = control, fill = control)) + geom_density(alpha = 0.4)
```

```
## Warning: Removed 8 rows containing non-finite values (stat_density).
```



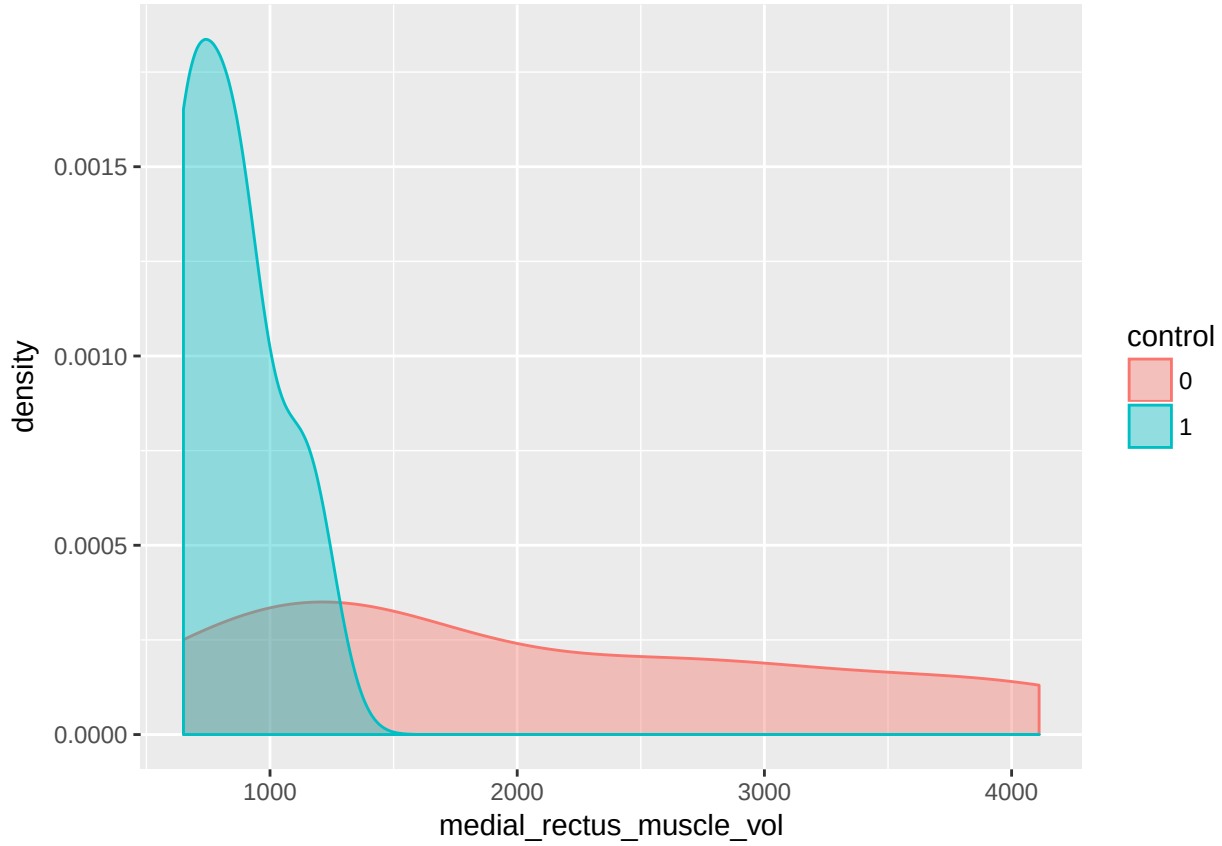

```
ggplot(TEDV, aes(x = MV.OV, color = control, fill = control)) + geom_density(alpha = 0.4)
```

```
## Warning: Removed 8 rows containing non-finite values (stat_density).
```




```
ggplot(TEDV, aes(x = medial_rectus_muscle_vol, color = control, fill = control)) + geom_density(alpha =
```

```
## Warning: Removed 48 rows containing non-finite values (stat_density).
```



Correlation Coefficient (Kitu)

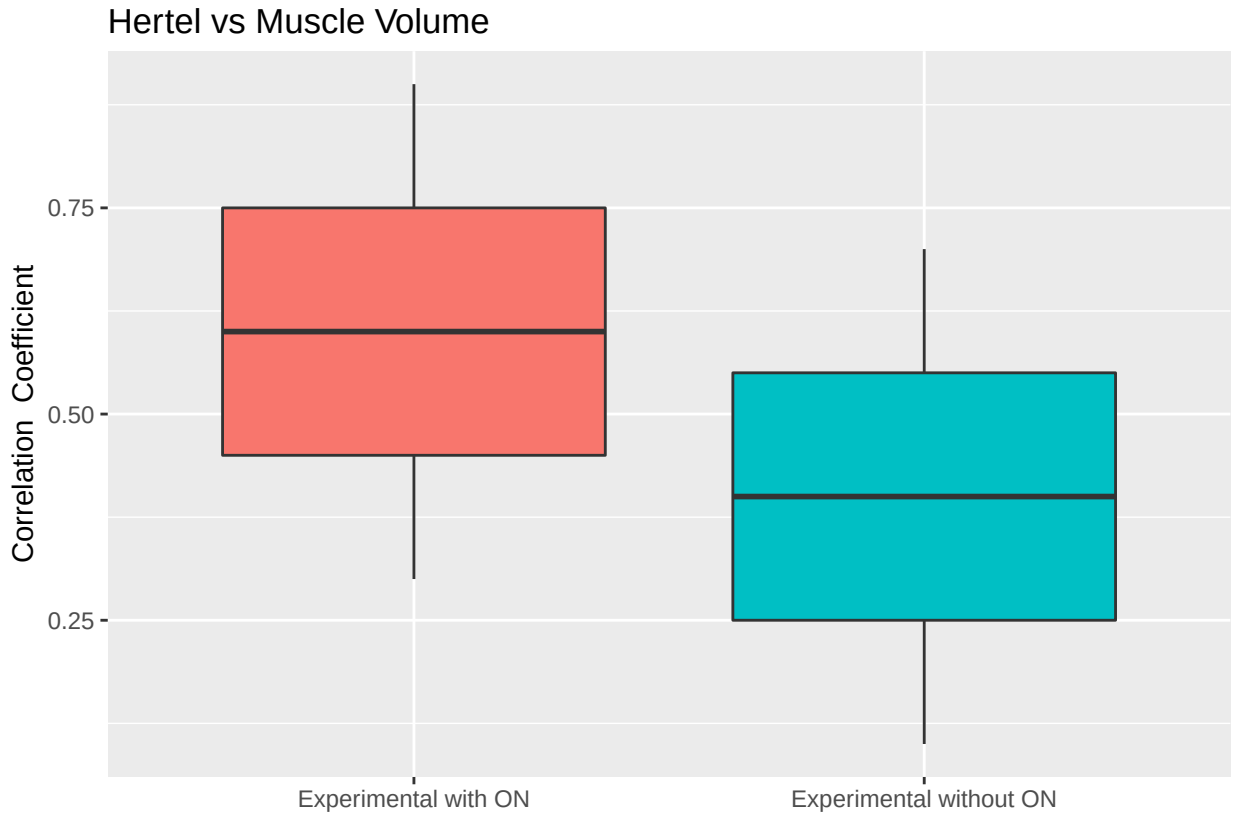
```
# new variable
TEDV$fat_over_muscle <- TEDV$fat_volume/TEDV$muscle_volume

# new dataframes
TEDV_exp_ON <- TEDV[TEDV$control == 0 & TEDV$optic_neuropathy == 1, ]
TEDV_exp_no_ON <- TEDV[TEDV$control == 0 & TEDV$optic_neuropathy == 0, ]

# correlation tests: do this manually for all variables
cor.test(TEDV_exp_ON$hertel, TEDV_exp_ON$muscle_volume, use = "complete.obs")
```

```
##
##  Pearson's product-moment correlation
##
## data:  TEDV_exp_ON$hertel and TEDV_exp_ON$muscle_volume
## t = 3.0489, df = 7, p-value = 0.01861
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.1828911 0.9452598
## sample estimates:
##       cor
## 0.7552756
```

```r
cor.test(TEDV_exp_no_ON$hertel, TEDV_exp_no_ON$muscle_volume, use = "complete.obs")
```

```
##
##  Pearson's product-moment correlation
##
## data:  TEDV_exp_no_ON$hertel and TEDV_exp_no_ON$muscle_volume
## t = 2.9455, df = 37, p-value = 0.005548
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.1394996 0.6605206
## sample estimates:
##       cor
## 0.4358336
```

```r
# make dataframe when significant
dat <- data.frame(
    x = c(1, 1, 1, 2, 2, 2 ),
    y = c(0.3, 0.6, 0.9, 0.1, 0.4, 0.7)
)

# rename variable
dat$x <- ifelse(dat$x == 1, "Experimental with ON", "Experimental without ON")

# plot boxplots for each time correlation coefficient is significant
ggplot(dat, aes(x = factor(x), y = y)) + geom_boxplot(aes(fill = factor(x))) + guides(fill = F) + ylab(
```



Modeling (Caitlin)

```
#this is how many non blind eyes vs how many blind eyes
table( TEDV$optic_neuropathy)
```

```
##
##  0  1
## 60  9
```

```
model_ON <-glm(optic_neuropathy~ CAS.score +  OSDI.score + lagophthalmos+  Strabismus.0.No.1.yes  +  he
summary(model_ON )
```

```
##
## Call:
## glm(formula = optic_neuropathy ~ CAS.score + OSDI.score + lagophthalmos +
##     Strabismus.0.No.1.yes + hertel + FV.OV + MV.OV + medial_bow +
##     decompression + medial_rectus_muscle_vol, family = binomial,
##     data = TEDV[TEDV$control == 0, ])
##
## Deviance Residuals:
##  [1]  0  0  0  0  0  0  0  0  0  0
##
## Coefficients: (1 not defined because of singularities)
##                             Estimate Std. Error z value Pr(>|z|)
## (Intercept)               -2.734e+02  9.061e+05       0        1
## CAS.score                  1.432e+01  1.382e+05       0        1
## OSDI.score                -2.130e+00  1.947e+04       0        1
## lagophthalmos              3.563e+01  1.842e+05       0        1
## Strabismus.0.No.1.yes             NA         NA      NA       NA
## hertel                    -3.593e+01  1.186e+05       0        1
## FV.OV                      1.084e+01  3.641e+04       0        1
## MV.OV                      1.178e+01  3.011e+04       0        1
## medial_bow                 1.125e+02  1.090e+06       0        1
## decompression              1.794e+02  9.339e+05       0        1
## medial_rectus_muscle_vol -2.578e-03  3.148e+02       0        1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 1.3460e+01  on 9  degrees of freedom
## Residual deviance: 4.2867e-10  on 0  degrees of freedom
##   (38 observations deleted due to missingness)
## AIC: 20
##
## Number of Fisher Scoring iterations: 23
```

```
model_ON_2 <- glm(optic_neuropathy ~ fat_muscle_ratio, family=binomial, data =  TEDV[TEDV$control == 0,
summary(model_ON_2)
```

```
##
## Call:
## glm(formula = optic_neuropathy ~ fat_muscle_ratio, family = binomial,
##     data = TEDV[TEDV$control == 0, ])
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
```

```
## -0.8961  -0.7379  -0.5325  -0.3888   2.5173
##
## Coefficients:
##                  Estimate Std. Error z value Pr(>|z|)
## (Intercept)       -0.3250     0.7863  -0.413    0.679
## fat_muscle_ratio  -1.6285     1.1091  -1.468    0.142
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 46.327  on 47  degrees of freedom
## Residual deviance: 43.614  on 46  degrees of freedom
## AIC: 47.614
##
## Number of Fisher Scoring iterations: 5
```

```
model_ON_3 <- glm(optic_neuropathy ~ FV.OV, family=binomial, data =  TEDV[TEDV$control == 0, ])
summary(model_ON_3)
```

```
##
## Call:
## glm(formula = optic_neuropathy ~ FV.OV, family = binomial, data = TEDV[TEDV$control ==
##     0, ])
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.9581  -0.6205  -0.4553  -0.3064   2.2210
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  0.05339    1.21942   0.044    0.965
## FV.OV       -0.06184    0.04172  -1.482    0.138
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 34.450  on 41  degrees of freedom
## Residual deviance: 31.967  on 40  degrees of freedom
##   (6 observations deleted due to missingness)
## AIC: 35.967
##
## Number of Fisher Scoring iterations: 5
```

```
model_ON_4 <- glm(optic_neuropathy ~ MV.OV, family=binomial, data =  TEDV[TEDV$control == 0, ])
summary(model_ON_4)
```

```
##
## Call:
## glm(formula = optic_neuropathy ~ MV.OV, family = binomial, data = TEDV[TEDV$control ==
##     0, ])
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.7968  -0.5751  -0.5102  -0.4522   2.0772
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
```

```
## (Intercept) -3.38777    2.20572  -1.536    0.125
## MV.OV        0.03218    0.04254   0.757    0.449
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 34.450  on 41  degrees of freedom
## Residual deviance: 33.873  on 40  degrees of freedom
##   (6 observations deleted due to missingness)
## AIC: 37.873
##
## Number of Fisher Scoring iterations: 4
```

```
model_ON_5 <- glm(optic_neuropathy ~ lagophthalmos, family=binomial, data =  TEDV[TEDV$control == 0, ])
summary(model_ON_5)
```

```
##
## Call:
## glm(formula = optic_neuropathy ~ lagophthalmos, family = binomial,
##     data = TEDV[TEDV$control == 0, ])
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.6849  -0.5556  -0.4476  -0.4476   2.1681
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept)    -2.2502     0.6772  -3.323 0.000891 ***
## lagophthalmos   0.4598     0.6337   0.726 0.468074
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 30.142  on 39  degrees of freedom
## Residual deviance: 29.633  on 38  degrees of freedom
##   (8 observations deleted due to missingness)
## AIC: 33.633
##
## Number of Fisher Scoring iterations: 4
```

```
model_ON_6 <- glm(optic_neuropathy ~ hertel, family=binomial, data =  TEDV[TEDV$control == 0, ])
summary(model_ON_6)
```

```
##
## Call:
## glm(formula = optic_neuropathy ~ hertel, family = binomial, data = TEDV[TEDV$control ==
##     0, ])
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.6629  -0.6467  -0.6418  -0.6302   1.8692
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept) -1.64330    1.96335  -0.837    0.403
```

```
## hertel       0.00799    0.08687   0.092    0.927
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 46.327  on 47  degrees of freedom
## Residual deviance: 46.319  on 46  degrees of freedom
## AIC: 50.319
##
## Number of Fisher Scoring iterations: 4
```

Table of Means to explain why nothing is important.

```
TEDV %>% group_by(optic_neuropathy) %>% summarize(mean(CAS.score, na.rm = TRUE), mean(Strabismus.0.No.1
```

```
## # A tibble: 2 x 7
##   optic_neuropathy `mean(CAS.score, na.rm = TRUE)`
##              <dbl>                           <dbl>
## 1                0                        2.666667
## 2                1                        2.666667
## # ... with 5 more variables: `mean(Strabismus.0.No.1.yes, na.rm =
## #   TRUE)` <dbl>, `mean(orbit_volume, na.rm = TRUE)` <dbl>,
## #   `mean(muscle_volume, na.rm = TRUE)` <dbl>, `mean(fat_volume, na.rm =
## #   TRUE)` <dbl>, `mean(medial_rectus_muscle_vol, na.rm = TRUE)` <dbl>
```

```
model_decompression <-glm(decompression~ CAS.score +  OSDI.score + lagophthalmos+  Strabismus.0.No.1.yes
summary(model_decompression)
```

```
##
## Call:
## glm(formula = decompression ~ CAS.score + OSDI.score + lagophthalmos +
##     Strabismus.0.No.1.yes + hertel + FV.OV + MV.OV + medial_bow +
##     medial_rectus_muscle_vol, data = TEDV[TEDV$control == 0,
##     ])
##
## Deviance Residuals:
##         1          4          8          9         15         46
##  0.055612   0.017907  -0.018442   0.000874  -0.067265  -0.075294
##        49         53         54         60
## -0.004257   0.024034  -0.004692   0.071522
##
## Coefficients: (1 not defined because of singularities)
##                             Estimate Std. Error t value Pr(>|t|)
## (Intercept)              -0.3136652  0.9182306  -0.342    0.790
## CAS.score                 0.0949968  0.1134866   0.837    0.556
## OSDI.score                0.0189648  0.0086575   2.191    0.273
## lagophthalmos             0.0785373  0.1808816   0.434    0.739
## Strabismus.0.No.1.yes            NA         NA      NA       NA
## hertel                    0.0273305  0.1240738   0.220    0.862
## FV.OV                    -0.0179793  0.0345942  -0.520    0.695
## MV.OV                    -0.0086762  0.0310507  -0.279    0.827
## medial_bow               -1.1083784  0.3672130  -3.018    0.204
## medial_rectus_muscle_vol  0.0002860  0.0001784   1.604    0.355
##
## (Dispersion parameter for gaussian family taken to be 0.01968114)
##
##     Null deviance: 1.600000  on 9  degrees of freedom
```

```
## Residual deviance: 0.019681  on 1  degrees of freedom
##   (38 observations deleted due to missingness)
## AIC: -13.928
##
## Number of Fisher Scoring iterations: 2
```

```
model_Strabismus<- glm(Strabismus.0.No.1.yes~ CAS.score+ Lagophthalmos.OD + Lagophthalmos.OS + Hertel.O
summary(model_Strabismus)
```

```
##
## Call:
## glm(formula = Strabismus.0.No.1.yes ~ CAS.score + Lagophthalmos.OD +
##     Lagophthalmos.OS + Hertel.OD + Hertel.OS + OSDI.score + OPTIC.NEUROPATHY..0.1. +
##     OPTIC.NEUROPATHY.EYE..OD.0..OS.1..OU.2. + MEDIAL.BOW.OD..0.1..0..No..1..Yes +
##     MEDIAL.BOW.OS..0.1..0..No..1..Yes + DECOMPRESSION.OD..1..0. +
##     DECOMPRESSION.OS..1..0. + FV.OV.OD + FV.OV.OS + MV.OV.OD +
##     MV.OV.OS + FV.OV.OS + R.Medial.Rectus.Muscle.Volume + Left.Medial.Rectus.Muscle.Volume,
##     family = binomial, data = TEDV_visible_cols[TEDV_visible_cols$control ==
##         0, ])
##
## Deviance Residuals:
## [1]  0  0  0  0
##
## Coefficients: (15 not defined because of singularities)
##                                       Estimate Std. Error z value
## (Intercept)                          2.357e+01  1.692e+05       0
## CAS.score                           -2.153e-07  3.785e+04       0
## Lagophthalmos.OD                     8.071e-07  1.463e+05       0
## Lagophthalmos.OS                    -9.686e-07  2.010e+05       0
## Hertel.OD                                   NA         NA      NA
## Hertel.OS                                   NA         NA      NA
## OSDI.score                                  NA         NA      NA
## OPTIC.NEUROPATHY..0.1.                      NA         NA      NA
## OPTIC.NEUROPATHY.EYE..OD.0..OS.1..OU.2.     NA         NA      NA
## MEDIAL.BOW.OD..0.1..0..No..1..Yes           NA         NA      NA
## MEDIAL.BOW.OS..0.1..0..No..1..Yes           NA         NA      NA
## DECOMPRESSION.OD..1..0.                     NA         NA      NA
## DECOMPRESSION.OS..1..0.                     NA         NA      NA
## FV.OV.OD                                    NA         NA      NA
## FV.OV.OS                                    NA         NA      NA
## MV.OV.OD                                    NA         NA      NA
## MV.OV.OS                                    NA         NA      NA
## R.Medial.Rectus.Muscle.Volume               NA         NA      NA
## Left.Medial.Rectus.Muscle.Volume            NA         NA      NA
##                                     Pr(>|z|)
## (Intercept)                                1
## CAS.score                                  1
## Lagophthalmos.OD                           1
## Lagophthalmos.OS                           1
## Hertel.OD                                 NA
## Hertel.OS                                 NA
## OSDI.score                                NA
## OPTIC.NEUROPATHY..0.1.                    NA
## OPTIC.NEUROPATHY.EYE..OD.0..OS.1..OU.2.   NA
## MEDIAL.BOW.OD..0.1..0..No..1..Yes         NA
```

```
## MEDIAL.BOW.OS..0.1..0..No..1..Yes             NA
## DECOMPRESSION.OD..1..0.                       NA
## DECOMPRESSION.OS..1..0.                       NA
## FV.OV.OD                                      NA
## FV.OV.OS                                      NA
## MV.OV.OD                                      NA
## MV.OV.OS                                      NA
## R.Medial.Rectus.Muscle.Volume                 NA
## Left.Medial.Rectus.Muscle.Volume              NA
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 0.000e+00  on 3  degrees of freedom
## Residual deviance: 4.661e-10  on 0  degrees of freedom
##   (20 observations deleted due to missingness)
## AIC: 8
##
## Number of Fisher Scoring iterations: 22
```

```
library(logistf)
```

```
## Warning: package 'logistf' was built under R version 3.4.4
```

```
decompression_log <- logistf(decompression~ CAS.score +  OSDI.score + lagophthalmos+  Strabismus.0.No.1
summary(decompression_log)
```

```
## logistf(formula = decompression ~ CAS.score + OSDI.score + lagophthalmos +
##     Strabismus.0.No.1.yes + hertel + FV.OV + MV.OV + medial_bow +
##     medial_rectus_muscle_vol, data = TEDV[TEDV$control == 0,
##     ])
##
## Model fitted by Penalized ML
## Confidence intervals and p-values by Profile Likelihood Profile Likelihood Profile Likelihood Profil
##
##                                 coef     se(coef)    lower 0.95
## (Intercept)              -4.738933e+00 1.034509e+01 -1.805894e+01
## CAS.score                 1.052394e-01 5.133092e-01 -6.047611e-01
## OSDI.score                6.948420e-02 1.425618e-01 -3.122314e-02
## lagophthalmos             1.191538e+00 1.565633e+00 -8.162645e-01
## Strabismus.0.No.1.yes    -2.466635e-02 4.877426e-01 -1.547153e+00
## hertel                    6.743252e-04 1.416775e-03 -1.174441e-02
## FV.OV                    -5.652883e-04 8.510291e-04 -1.652260e-02
## MV.OV                     9.702845e-03 9.861444e-03 -2.962117e-02
## medial_bow               -6.957945e-01 6.994267e-01 -5.751928e+00
## medial_rectus_muscle_vol  2.916356e-11 7.107756e-08 -1.643230e-06
##                            upper 0.95        Chisq         p
## (Intercept)              4.190581e+00 0.000000e+00 1.0000000
## CAS.score                6.759871e-01 0.000000e+00 1.0000000
## OSDI.score               2.171606e-01 1.338059e+00 0.2473766
## lagophthalmos            4.505138e+00 7.404121e-01 0.3895289
## Strabismus.0.No.1.yes    5.364591e+00 0.000000e+00 1.0000000
## hertel                   2.724841e-02 3.724401e-01 0.5416772
## FV.OV                    2.062223e-02 1.879952e-01 0.6645905
## MV.OV                    8.489655e-02 2.050068e-01 0.6507095
## medial_bow               2.086171e+00 4.419027e-01 0.5062055
```

```
## medial_rectus_muscle_vol 1.643218e-06 6.735226e-08 0.9997929
##
## Likelihood ratio test=1.916964 on 9 df, p=0.9927136, n=10
## Wald test = 3.120637 on 9 df, p = 0.9593193
##
## Covariance-Matrix:
##                [,1]          [,2]          [,3]          [,4]
##  [1,]  1.070209e+02 -4.262530e+00 -1.451299e+00 -7.091261e+00
##  [2,] -4.262530e+00  2.634863e-01  5.374691e-02  1.492419e-01
##  [3,] -1.451299e+00  5.374691e-02  2.032386e-02  8.039304e-02
##  [4,] -7.091261e+00  1.492419e-01  8.039304e-02  2.451206e+00
##  [5,] -3.948417e-01  3.758788e-03  2.365198e-03  8.357053e-03
##  [6,]  7.331637e-03 -2.082105e-04 -1.086453e-04 -2.871671e-04
##  [7,]  7.910405e-05 -6.352048e-05  7.501319e-07  1.756484e-04
##  [8,] -4.890741e-03  1.117479e-03  4.218882e-05 -2.697743e-03
##  [9,]  3.515351e-01 -7.942807e-02 -3.060982e-03  1.913420e-01
## [10,]  9.723820e-11 -1.131644e-13 -1.616797e-12 -3.509257e-12
##                [,5]          [,6]          [,7]          [,8]
##  [1,] -3.948417e-01  7.331637e-03  7.910405e-05 -4.890741e-03
##  [2,]  3.758788e-03 -2.082105e-04 -6.352048e-05  1.117479e-03
##  [3,]  2.365198e-03 -1.086453e-04  7.501319e-07  4.218882e-05
##  [4,]  8.357053e-03 -2.871671e-04  1.756484e-04 -2.697743e-03
##  [5,]  2.378929e-01 -4.254316e-05  1.783353e-05 -2.676269e-04
##  [6,] -4.254316e-05  2.007253e-06 -8.752603e-07  8.786442e-06
##  [7,]  1.783353e-05 -8.752603e-07  7.242506e-07 -6.306052e-06
##  [8,] -2.676269e-04  8.786442e-06 -6.306052e-06  9.724808e-05
##  [9,]  1.897340e-02 -6.240307e-04  4.441335e-04 -6.896254e-03
## [10,]  3.108326e-14  4.397383e-14 -6.363041e-14 -2.731600e-14
##                [,9]         [,10]
##  [1,]  3.515351e-01  9.723820e-11
##  [2,] -7.942807e-02 -1.131644e-13
##  [3,] -3.060982e-03 -1.616797e-12
##  [4,]  1.913420e-01 -3.509257e-12
##  [5,]  1.897340e-02  3.108326e-14
##  [6,] -6.240307e-04  4.397383e-14
##  [7,]  4.441335e-04 -6.363041e-14
##  [8,] -6.896254e-03 -2.731600e-14
##  [9,]  4.891977e-01 -1.387398e-11
## [10,] -1.387398e-11  5.052020e-15
```

```
model_ON_logistf <- logistf(optic_neuropathy~ CAS.score +  OSDI.score + lagophthalmos+  Strabismus.0.No
summary(model_ON_logistf)
```

```
## logistf(formula = optic_neuropathy ~ CAS.score + OSDI.score +
##     lagophthalmos + Strabismus.0.No.1.yes + hertel + FV.OV +
##     MV.OV + medial_bow + decompression + medial_rectus_muscle_vol,
##     data = TEDV[TEDV$control == 0, ], family = binomial)
##
## Model fitted by Penalized ML
## Confidence intervals and p-values by Profile Likelihood Profile Likelihood Profile Likelihood Profil
##
##                                 coef     se(coef)    lower 0.95
## (Intercept)              -1.406250e+00 1.902286e+01 -3.714719e+01
## CAS.score                 1.659109e-02 5.404048e-01 -5.474668e-01
## OSDI.score                1.655920e-02 2.877124e-01 -8.361266e-02
```

```
## lagophthalmos             4.024792e-01 1.432840e+00 -8.322116e-01
## Strabismus.0.No.1.yes     1.421852e-03 4.065993e-01 -4.927741e+00
## hertel                   -5.314775e-05 1.913279e-03 -1.741003e-02
## FV.OV                     5.578744e-05 2.001672e-03 -1.168674e-02
## MV.OV                    -3.658710e-04 8.462519e-03 -5.191529e-02
## medial_bow                3.370655e-02 6.828944e-01 -3.611438e+00
## decompression            -8.329804e-03 5.019008e-01 -2.453959e+00
## medial_rectus_muscle_vol  4.073133e-13 5.796374e-08 -7.420365e-07
##                             upper 0.95      Chisq         p
## (Intercept)               5.098175e+00 0.00000000 1.0000000
## CAS.score                 7.172519e-01 0.02552855 0.8730571
## OSDI.score                2.659405e-01 0.21328610 0.6442039
## lagophthalmos             4.325294e+00 0.77445283 0.3788430
## Strabismus.0.No.1.yes     4.010803e+00 0.00000000 1.0000000
## hertel                    1.539853e-02 0.00000000 1.0000000
## FV.OV                     1.246485e-02 0.00000000 1.0000000
## MV.OV                     4.373491e-02 0.00000000 1.0000000
## medial_bow                3.653056e+00 0.00000000 1.0000000
## decompression             2.760320e+00 0.00000000 1.0000000
## medial_rectus_muscle_vol 7.421017e-07 0.00000000 1.0000000
##
## Likelihood ratio test=0.8764926 on 10 df, p=0.9999063, n=10
## Wald test = 0.08758449 on 10 df, p = 1
##
## Covariance-Matrix:
##                [,1]          [,2]          [,3]          [,4]
##  [1,]  3.618691e+02 -8.476400e+00 -5.448369e+00 -1.163909e+01
##  [2,] -8.476400e+00  2.920374e-01  1.221397e-01  2.469916e-01
##  [3,] -5.448369e+00  1.221397e-01  8.277844e-02  1.558220e-01
##  [4,] -1.163909e+01  2.469916e-01  1.558220e-01  2.053031e+00
##  [5,] -8.114153e-01  1.287400e-02  9.977153e-03  1.682275e-02
##  [6,]  3.273957e-02 -6.983883e-04 -5.029538e-04 -6.909124e-04
##  [7,] -3.224697e-02  6.236511e-04  4.993490e-04  6.857887e-04
##  [8,] -1.824937e-02  9.962969e-04  2.633104e-04 -1.498021e-03
##  [9,] -7.052776e+00  9.530383e-02  1.104579e-01  2.692958e-01
## [10,]  8.239877e+00 -1.636346e-01 -1.274796e-01 -1.615925e-01
## [11,] -2.179878e-10  5.930914e-12  3.289451e-12  2.795639e-12
##                [,5]          [,6]          [,7]          [,8]
##  [1,] -8.114153e-01  3.273957e-02 -3.224697e-02 -1.824937e-02
##  [2,]  1.287400e-02 -6.983883e-04  6.236511e-04  9.962969e-04
##  [3,]  9.977153e-03 -5.029538e-04  4.993490e-04  2.633104e-04
##  [4,]  1.682275e-02 -6.909124e-04  6.857887e-04 -1.498021e-03
##  [5,]  1.653230e-01 -7.301245e-05  6.152505e-05 -1.591337e-04
##  [6,] -7.301245e-05  3.660636e-06 -3.375547e-06  1.661929e-06
##  [7,]  6.152505e-05 -3.375547e-06  4.006691e-06  1.935171e-06
##  [8,] -1.591337e-04  1.661929e-06  1.935171e-06  7.161423e-05
##  [9,]  2.563208e-02 -9.089512e-04  8.391148e-04 -3.999933e-03
## [10,] -1.423336e-02  7.813425e-04 -9.657515e-04 -1.037963e-03
## [11,]  4.962544e-13  1.305713e-16 -5.653166e-15  1.909903e-14
##                [,9]         [,10]         [,11]
##  [1,] -7.052776e+00  8.239877e+00 -2.179878e-10
##  [2,]  9.530383e-02 -1.636346e-01  5.930914e-12
##  [3,]  1.104579e-01 -1.274796e-01  3.289451e-12
##  [4,]  2.692958e-01 -1.615925e-01  2.795639e-12
```

```
##  [5,]  2.563208e-02 -1.423336e-02  4.962544e-13
##  [6,] -9.089512e-04  7.813425e-04  1.305713e-16
##  [7,]  8.391148e-04 -9.657515e-04 -5.653166e-15
##  [8,] -3.999933e-03 -1.037963e-03  1.909903e-14
##  [9,]  4.663448e-01 -1.818500e-01 -2.951128e-12
## [10,] -1.818500e-01  2.519044e-01 -8.913479e-12
## [11,] -2.951128e-12 -8.913479e-12  3.359796e-15
```

out of these there are too many predictors we need to decide which ones to use

```
model_Strabismus_logistf<- logistf(Strabismus.0.No.1.yes~ CAS.score+ Lagophthalmos.OD + Lagophthalmos.OS
summary(model_Strabismus_logistf)
```

Muscle vs Orbital

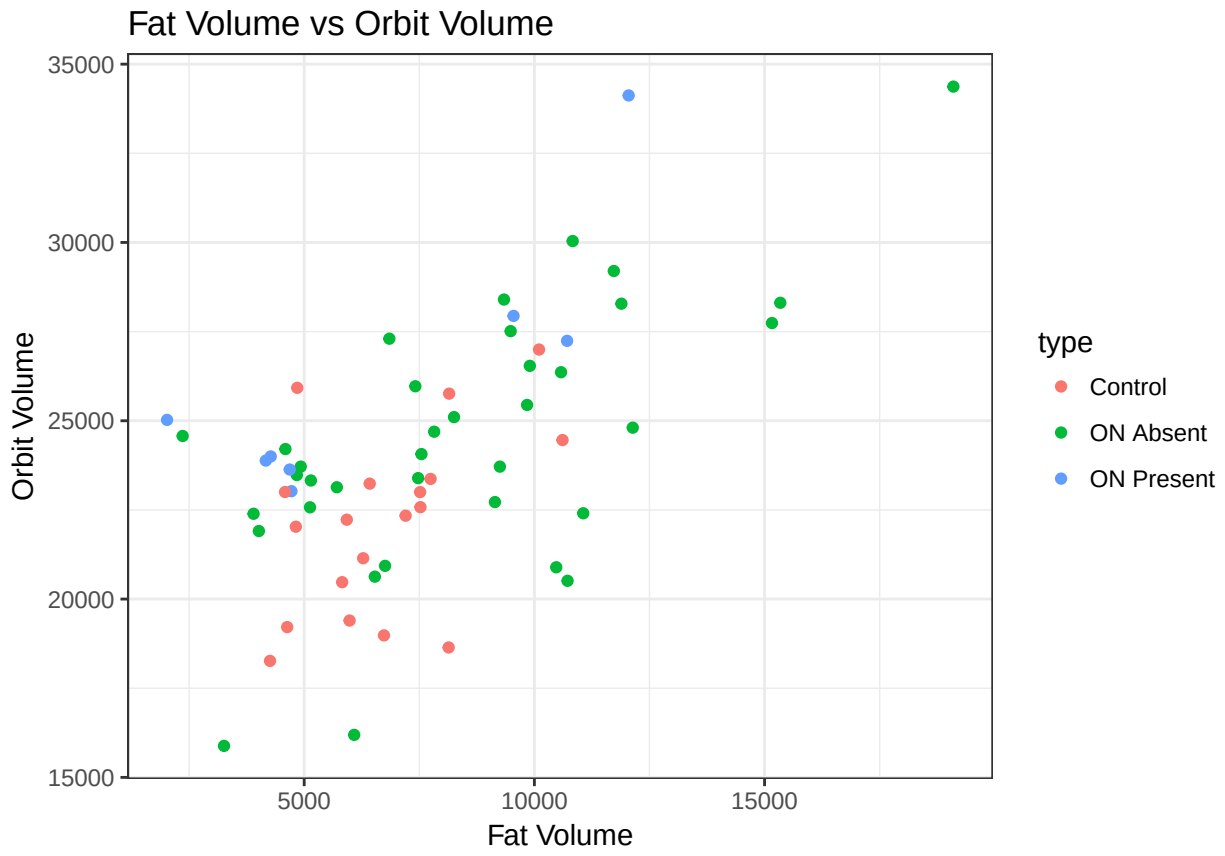
```
#make a new column that is "control" "ON present" "ON absent"
TEDV$type <- '0'
TEDV[TEDV$optic_neuropathy== 1,'type'] <- 'ON Present'
TEDV[TEDV$optic_neuropathy== 0, 'type'] <- 'ON Absent'
TEDV[TEDV$control== 1,'type'] <- 'Control'
names(TEDV)
```

```
##  [1] "Time.of.Image...Date.of.visit" "Age"
##  [3] "CAS.score"                     "OSDI.score"
##  [5] "baseline.visit.date"           "time.from.onset"
##  [7] "Strabismus.0.No.1.yes"         "control"
##  [9] "OD_or_OS"                      "optic_neuropathy"
## [11] "lagophthalmos"                 "hertel"
## [13] "medial_bow"                    "decompression"
## [15] "fat_volume"                    "muscle_volume"
## [17] "orbit_volume"                  "FV.OV"
## [19] "MV.OV"                         "medial_rectus_muscle_vol"
## [21] "fat_muscle_ratio"              "fat_over_muscle"
## [23] "type"
```

Fat vs age Fat vs CAS.Score Fat vs hertel

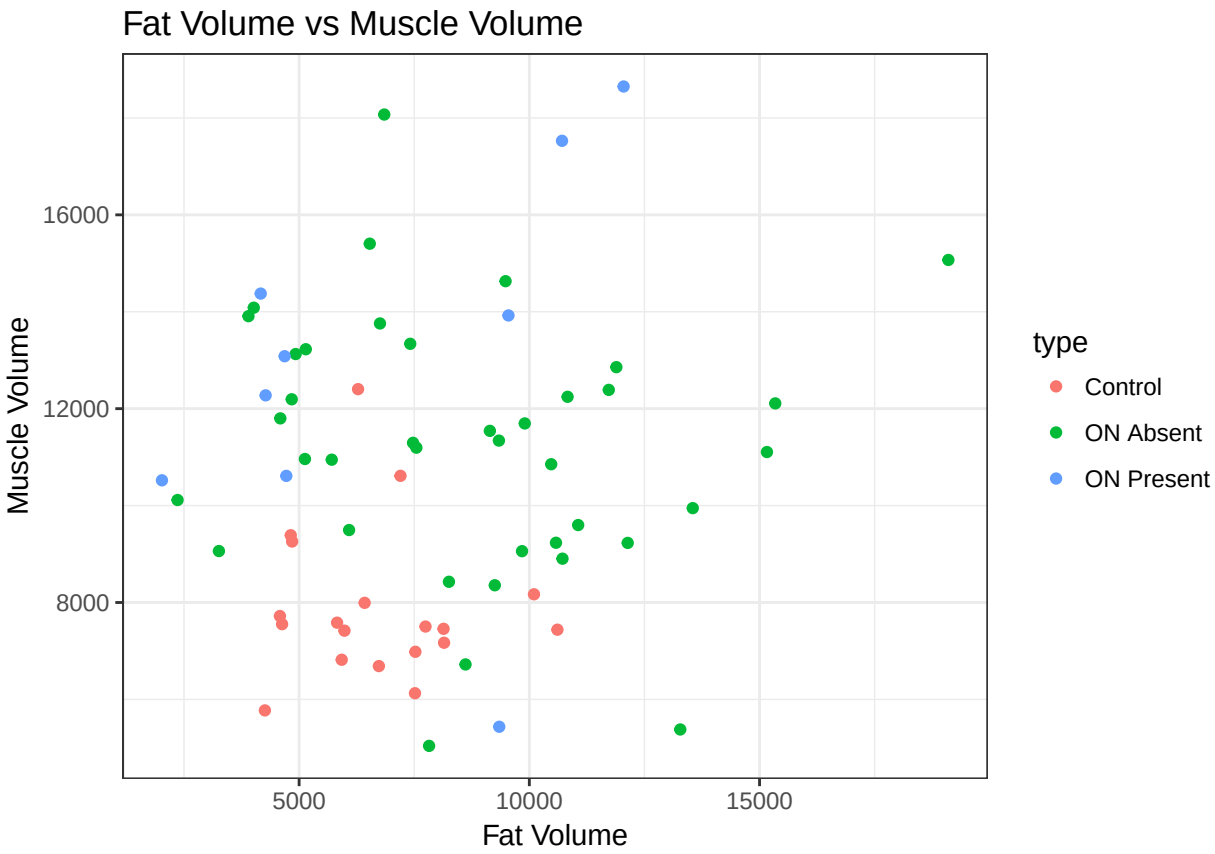
```
#EXPLORING THE RELATIONSHIP BETWEEN FAT, MUSCLE, and ORBIT
par(mfrow=c(3,1))
ggplot(TEDV, aes(fat_volume, orbit_volume)) + geom_point(aes(color = type))+ ggtitle("Fat Volume vs Orbi
```

```
## Warning: Removed 6 rows containing missing values (geom_point).
```



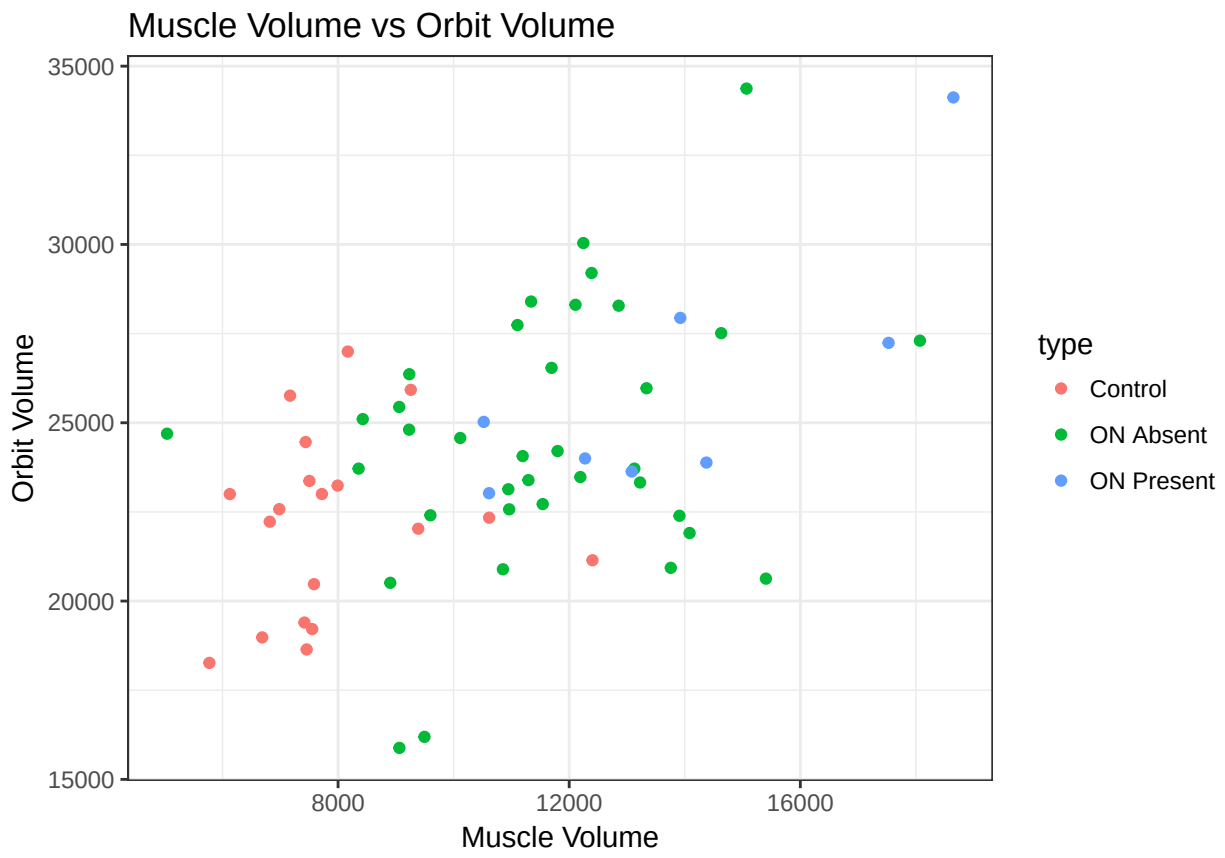

```
#INTERESTING - more muscle less fat
ggplot(TEDV, aes(fat_volume, muscle_volume)) + geom_point(aes(color = type))+ ggtitle("Fat Volume vs Mus
```

```
## Warning: Removed 2 rows containing missing values (geom_point).
```



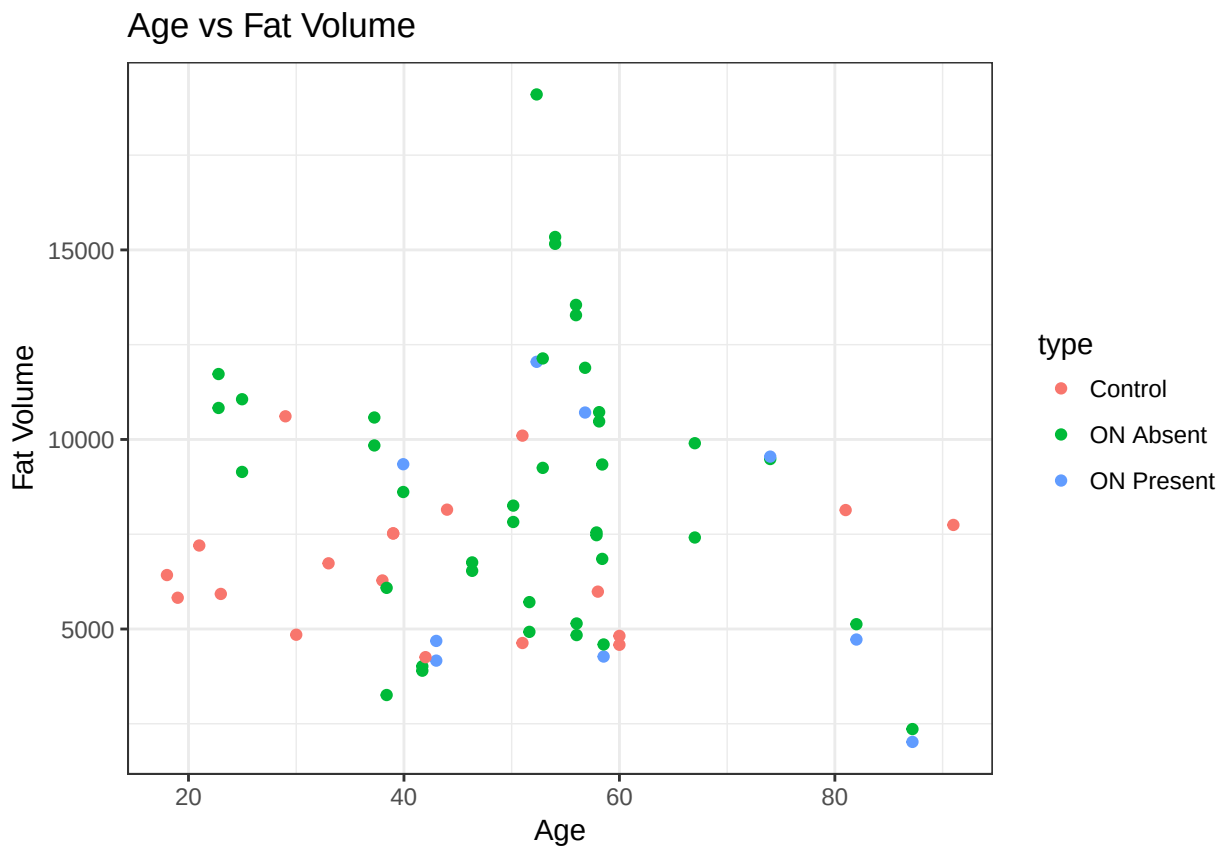

```
ggplot(TEDV, aes( muscle_volume, orbit_volume )) + geom_point(aes(color = type))+ ggtitle("Muscle Volume
```

```
## Warning: Removed 6 rows containing missing values (geom_point).
```



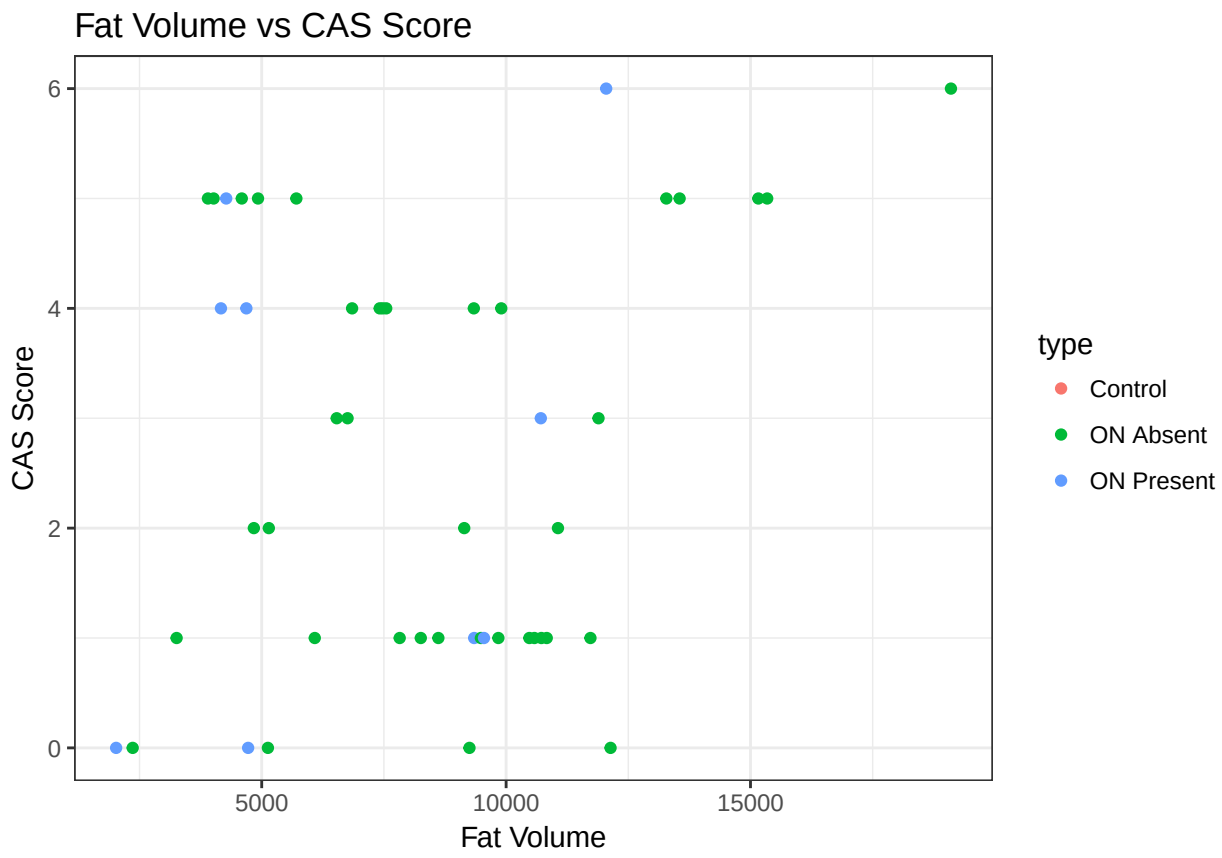

```
par(mfrow= c(1,1))

#EXPLORING FAT IN GENERAL
par(mfrow=c(3,1))
# not very interesting most variation at age 60
ggplot(TEDV, aes(Age, fat_volume)) + geom_point(aes(color = type))+ ggtitle("Age vs Fat Volume") +xlab(
```

```
## Warning: Removed 2 rows containing missing values (geom_point).
```



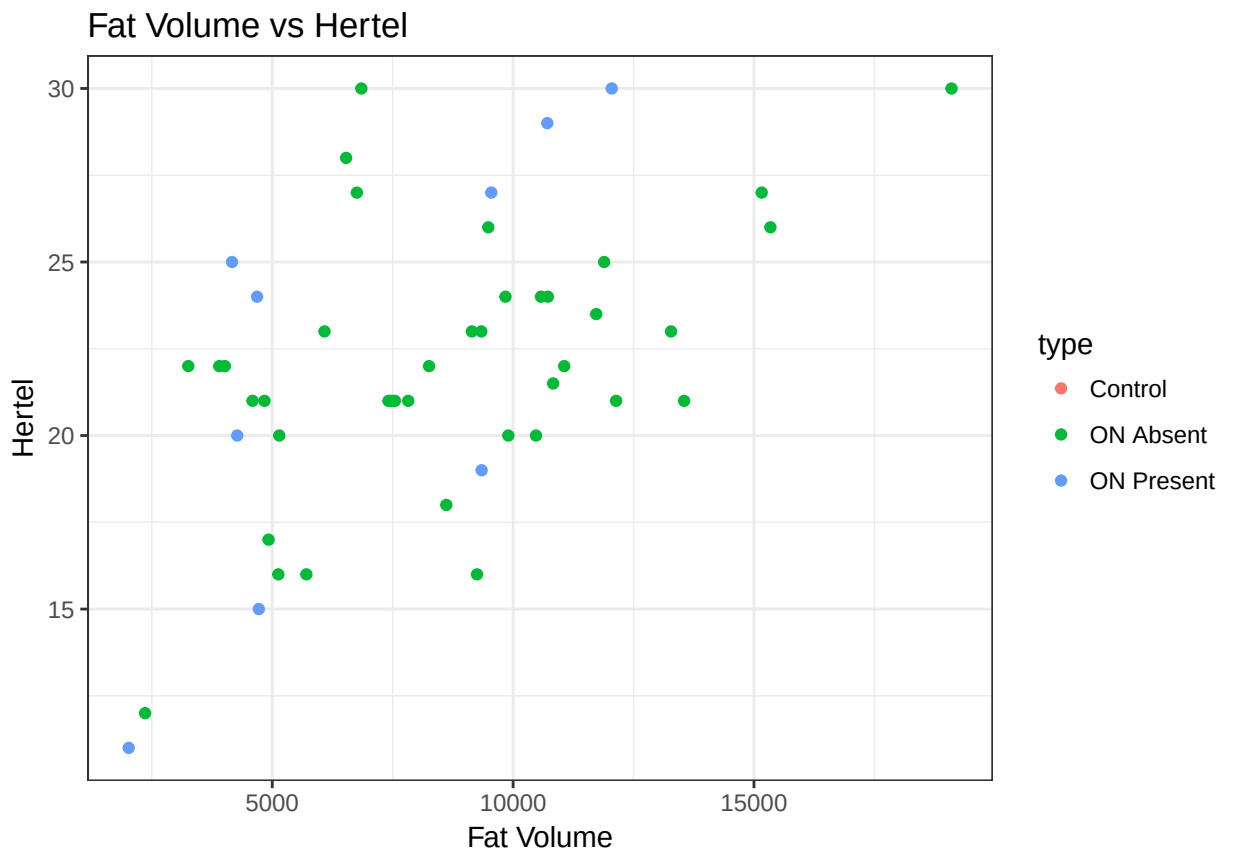

```
#not interesting
ggplot(TEDV, aes(fat_volume, CAS.score)) + geom_point(aes(color = type))+ ggtitle("Fat Volume vs CAS Sc
```

```
## Warning: Removed 21 rows containing missing values (geom_point).
```




```
#nothing significant... not measured for control group
ggplot(TEDV, aes(fat_volume, hertel)) + geom_point(aes(color = type))+ ggtitle("Fat Volume vs Hertel") +
```

```
## Warning: Removed 21 rows containing missing values (geom_point).
```




```
par(mfrow= c(1,1))
```

Correlation Matrix (Niamh)

```
TEDV2 <- cbind(TEDV_replicated[,c(1,2,3,8,9,10,13,30,31,32)],lagophthalmos,  hertel,medial_bow,decompres
names(TEDV2)
```

```
##  [1] "Time.of.Image...Date.of.visit" "Age"
##  [3] "CAS.score"                     "OSDI.score"
##  [5] "baseline.visit.date"           "time.from.onset"
##  [7] "Strabismus.0.No.1.yes"         "control"
##  [9] "OD_or_OS"                      "optic_neuropathy"
## [11] "lagophthalmos"                 "hertel"
## [13] "medial_bow"                    "decompression"
## [15] "fat_volume"                    "muscle_volume"
## [17] "orbit_volume"                  "FV.OV"
## [19] "MV.OV"                         "medial_rectus_muscle_vol"
```

```
##Remove controls and irrelevant columns
TEDV_exp<-subset(TEDV2, TEDV$control==0)
names(TEDV_exp)
```

```
##  [1] "Time.of.Image...Date.of.visit" "Age"
##  [3] "CAS.score"                     "OSDI.score"
##  [5] "baseline.visit.date"           "time.from.onset"
```

```
##  [7] "Strabismus.0.No.1.yes"         "control"
##  [9] "OD_or_OS"                      "optic_neuropathy"
## [11] "lagophthalmos"                 "hertel"
## [13] "medial_bow"                    "decompression"
## [15] "fat_volume"                    "muscle_volume"
## [17] "orbit_volume"                  "FV.OV"
## [19] "MV.OV"                         "medial_rectus_muscle_vol"
```

```
TEDV_exp$Time.of.Image...Date.of.visit<-NULL
TEDV_exp$baseline.visit.date<-NULL
TEDV_exp$time.from.onset<-NULL
TEDV_exp$control<-NULL
TEDV_exp$OD_or_OS<-NULL
#convert to factors
TEDV_exp$CAS.score<-as.numeric(TEDV_exp$CAS.score)
TEDV_exp$Strabismus.0.No.1.yes<-factor(TEDV_exp$Strabismus.0.No.1.yes)
TEDV_exp$optic_neuropathy<-factor(TEDV_exp$optic_neuropathy)
TEDV_exp$medial_bow<-factor(TEDV_exp$medial_bow)
TEDV_exp$decompression<-factor(TEDV_exp$decompression)

## Correlation matrix
library(vcd)
```

```
## Warning: package 'vcd' was built under R version 3.4.3
```

```
## Loading required package: grid
```

```
p_mat<-matrix(nrow=ncol(TEDV_exp), ncol=ncol(TEDV_exp))
cor_mat<-matrix(nrow=ncol(TEDV_exp), ncol=ncol(TEDV_exp))

for (i in 1:ncol(TEDV_exp)){
  for (j in 1:ncol(TEDV_exp)){
    x<-TEDV_exp[[i]]
    y<-TEDV_exp[[j]]
    if (class(x)=="numeric" & class(y)=="numeric"){
      c<-cor.test(x, y)
      cor_mat[i,j]<-c$estimate
      p_mat[i,j]<-c$p.value
    }
    if ((class(x)=="factor" & class(y)=="factor")){
      tab<-xtabs(~ x+y)
      res<-assocstats(tab)
      cor_mat[i,j]<-res$phi
      p_mat[i,j]<-res$chisq_tests[6]
    }
    if ((class(x)=="factor" & class(y)=="numeric")|(class(x)=="numeric" & class(y)=="factor")){
      x<-as.numeric(x)
      y<-as.numeric(y)
      c<-cor.test(x,y)
      c<-cor.test(x, y)
      cor_mat[i,j]<-c$estimate
      p_mat[i,j]<-c$p.value
    }
  }
}
```

```
length(cor_mat)
```

```
## [1] 225
```

```
## format for corrplot
nams<-c("Age", "CAS", "OSDI", "Strab", "ON", "lago", "hertel", "bowing", "decom", "FV", "MV", "OV", "FV

colnames(cor_mat)<-nams
rownames(cor_mat)<-nams

colnames(p_mat)<-nams
rownames(p_mat)<-nams

options(digits = 2)
cor_mat
```

```
##           Age    CAS   OSDI  Strab     ON   lago hertel  bowing decom
## Age     1.000 -0.086  0.681  0.317  0.219  0.072 -0.340  0.1189 0.494
## CAS    -0.086  1.000  0.489  0.428  0.000  0.084  0.408  0.4660 0.170
## OSDI    0.681  0.489  1.000  0.681  0.049 -0.057 -0.031  0.4533 0.423
## Strab   0.317  0.428  0.681  1.000  0.027     NA -0.108  0.3026 0.348
## ON      0.219  0.000  0.049  0.027  1.000     NA  0.013  0.3055 0.266
## lago    0.072  0.084 -0.057     NA     NA     NA  0.234      NA    NA
## hertel -0.340  0.408 -0.031 -0.108  0.013  0.234  1.000  0.1654 0.186
## bowing  0.119  0.466  0.453  0.303  0.306     NA  0.165  1.0000 0.290
## decom   0.494  0.170  0.423  0.348  0.266     NA  0.186  0.2901 1.000
## FV     -0.224  0.191  0.035  0.012 -0.201  0.148  0.522 -0.0083 0.237
## MV      0.103  0.454  0.106  0.229  0.226  0.036  0.534  0.1598 0.159
## OV      0.090  0.309  0.110  0.093  0.175  0.370  0.369  0.1618 0.123
## FVOV   -0.374  0.030 -0.141 -0.156 -0.237 -0.025  0.554 -0.2446 0.158
## MVOV   -0.024  0.346  0.016  0.184  0.117 -0.210  0.321  0.1493 0.081
## MRMV   -0.222  0.209  0.052 -0.220  0.370 -0.248  0.631  0.4043 0.398
##              FV     MV     OV   FVOV   MVOV   MRMV
## Age     -0.2239  0.103  0.090 -0.374 -0.024 -0.222
## CAS      0.1910  0.454  0.309  0.030  0.346  0.209
## OSDI     0.0348  0.106  0.110 -0.141  0.016  0.052
## Strab    0.0125  0.229  0.093 -0.156  0.184 -0.220
## ON      -0.2010  0.226  0.175 -0.237  0.117  0.370
## lago     0.1483  0.036  0.370 -0.025 -0.210 -0.248
## hertel   0.5218  0.534  0.369  0.554  0.321  0.631
## bowing  -0.0083  0.160  0.162 -0.245  0.149  0.404
## decom    0.2370  0.159  0.123  0.158  0.081  0.398
## FV       1.0000 -0.037  0.621  0.923 -0.332  0.314
## MV      -0.0374  1.000  0.415 -0.076  0.728  0.655
## OV       0.6214  0.415  1.000  0.296 -0.299  0.557
## FVOV     0.9230 -0.076  0.296  1.000 -0.285  0.526
## MVOV    -0.3320  0.728 -0.299 -0.285  1.000  0.200
## MRMV     0.3137  0.655  0.557  0.526  0.200  1.000
```

```
p_mat
```

```
##            Age    CAS    OSDI   Strab      ON   lago  hertel  bowing
## Age    0.0e+00 0.5612 1.3e-06 2.8e-02 1.3e-01 0.6567 1.8e-02 4.6e-01
## CAS    5.6e-01 0.0000 1.4e-03 2.4e-03 1.0e+00 0.6053 4.0e-03 2.4e-03
## OSDI   1.3e-06 0.0014 0.0e+00 1.3e-06 7.6e-01 0.7251 8.5e-01 3.3e-03
```

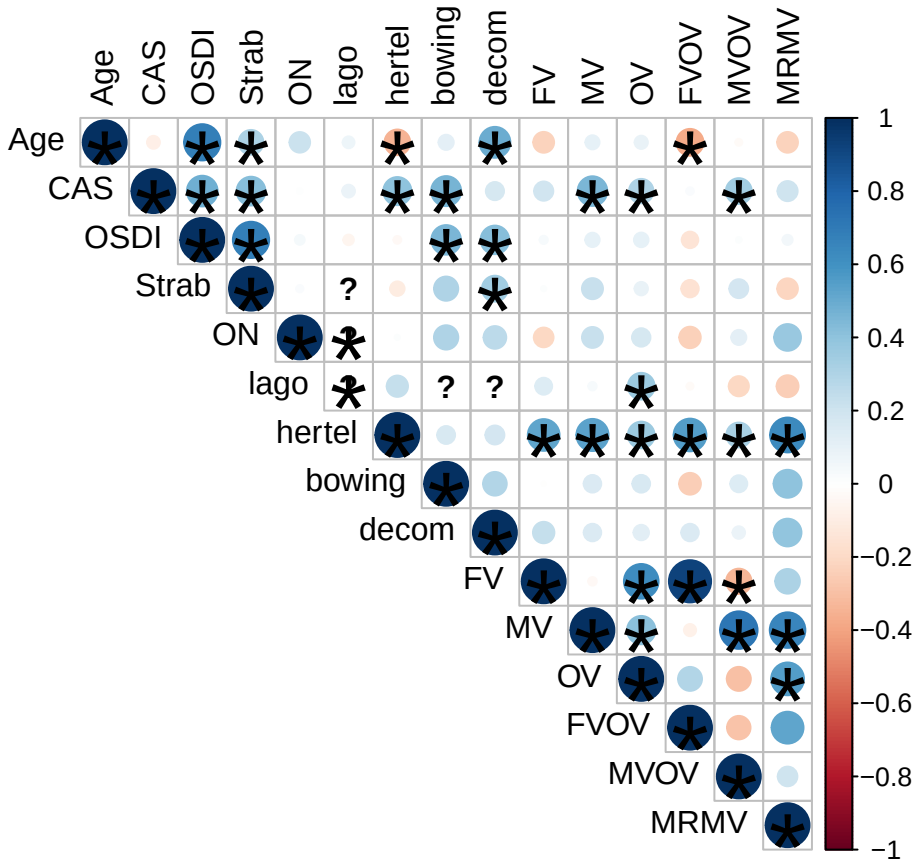
```
## Strab  2.8e-02 0.0024 1.3e-06 4.3e-12 8.5e-01 0.4285 4.7e-01 5.6e-02
## ON     1.3e-01 1.0000 7.6e-01 8.5e-01 4.3e-12 0.0065 9.3e-01 5.3e-02
## lago   6.6e-01 0.6053 7.3e-01 4.3e-01 6.5e-03 0.0000 1.5e-01 4.0e-01
## hertel 1.8e-02 0.0040 8.5e-01 4.7e-01 9.3e-01 0.1457 0.0e+00 3.1e-01
## bowing 4.6e-01 0.0024 3.3e-03 5.6e-02 5.3e-02 0.4002 3.1e-01 2.5e-10
## decom  1.2e-03 0.2940 6.5e-03 2.8e-02 9.3e-02 0.1972 2.5e-01 6.7e-02
## FV     1.3e-01 0.1935 8.3e-01 9.3e-01 1.7e-01 0.3611 1.4e-04 9.6e-01
## MV     4.9e-01 0.0012 5.1e-01 1.2e-01 1.2e-01 0.8260 9.2e-05 3.2e-01
## OV     5.6e-01 0.0415 5.2e-01 5.5e-01 2.5e-01 0.0265 1.4e-02 3.5e-01
## FVOV   1.5e-02 0.8528 4.1e-01 3.2e-01 1.3e-01 0.8862 1.4e-04 1.5e-01
## MVOV   8.8e-01 0.0249 9.3e-01 2.4e-01 4.6e-01 0.2194 3.8e-02 3.8e-01
## MRMV   4.1e-01 0.4370 8.7e-01 4.1e-01 1.6e-01 0.4375 8.8e-03 1.9e-01
##          decom      FV      MV      OV     FVOV    MVOV     MRMV
## Age    1.2e-03 1.3e-01 4.9e-01 5.6e-01  1.5e-02 8.8e-01  4.1e-01
## CAS    2.9e-01 1.9e-01 1.2e-03 4.2e-02  8.5e-01 2.5e-02  4.4e-01
## OSDI   6.5e-03 8.3e-01 5.1e-01 5.2e-01  4.1e-01 9.3e-01  8.7e-01
## Strab  2.8e-02 9.3e-01 1.2e-01 5.5e-01  3.2e-01 2.4e-01  4.1e-01
## ON     9.3e-02 1.7e-01 1.2e-01 2.5e-01  1.3e-01 4.6e-01  1.6e-01
## lago   2.0e-01 3.6e-01 8.3e-01 2.6e-02  8.9e-01 2.2e-01  4.4e-01
## hertel 2.5e-01 1.4e-04 9.2e-05 1.4e-02  1.4e-04 3.8e-02  8.8e-03
## bowing 6.7e-02 9.6e-01 3.2e-01 3.5e-01  1.5e-01 3.8e-01  1.9e-01
## decom  2.5e-10 1.4e-01 3.3e-01 4.7e-01  3.6e-01 6.4e-01  2.0e-01
## FV     1.4e-01 0.0e+00 8.0e-01 6.8e-06  3.5e-18 3.2e-02  2.4e-01
## MV     3.3e-01 8.0e-01 0.0e+00 5.1e-03  6.3e-01 4.7e-08  5.9e-03
## OV     4.7e-01 6.8e-06 5.1e-03 0.0e+00  5.7e-02 5.5e-02  3.8e-02
## FVOV   3.6e-01 3.5e-18 6.3e-01 5.7e-02 1.1e-308 6.7e-02  5.3e-02
## MVOV   6.4e-01 3.2e-02 4.7e-08 5.5e-02  6.7e-02 0.0e+00  4.9e-01
## MRMV   2.0e-01 2.4e-01 5.9e-03 3.8e-02  5.3e-02 4.9e-01 7.1e-109
```

```
##plot
library(corrplot)
```

```
## Warning: package 'corrplot' was built under R version 3.4.3
```

```
## corrplot 0.84 loaded
```

```
corrplot(cor_mat, type="upper", tl.col = "black", p.mat = p_mat, sig.level = 0.05, insig = "label_sig")
```



Wilcoxon tests (Mrinalini)

```
library(dplyr)
#Data
TEDV %>% filter( control== 0) -> tedv_exp
# MV/FV
tedv_exp$MV.FV<- tedv_exp$muscle_volume/ tedv_exp$fat_volume

#ON
wilcox.test( tedv_exp$lagophthalmos ~tedv_exp$optic_neuropathy)
```

```
## Warning in wilcox.test.default(x = c(0, 2, 1, 0.5, 1, 2, 2, 0, 0, 0, 1, :
## cannot compute exact p-value with ties
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  tedv_exp$lagophthalmos by tedv_exp$optic_neuropathy
## W = 70, p-value = 0.5
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test( tedv_exp$hertel ~tedv_exp$optic_neuropathy)
```

```
## Warning in wilcox.test.default(x = c(22, 30, 24, 21.5, 22, 23, 26, 21,
## 16, : cannot compute exact p-value with ties
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  tedv_exp$hertel by tedv_exp$optic_neuropathy
## W = 200, p-value = 0.8
## alternative hypothesis: true location shift is not equal to 0
```

```
#wilcox.test( tedv_exp$F ~tedv_exp$optic_neuropathy)
wilcox.test( tedv_exp$muscle_volume ~tedv_exp$optic_neuropathy)
```

```
##
##  Wilcoxon rank sum test
##
## data:  tedv_exp$muscle_volume by tedv_exp$optic_neuropathy
## W = 100, p-value = 0.1
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test( tedv_exp$orbit_volume ~tedv_exp$optic_neuropathy)
```

```
##
##  Wilcoxon rank sum test
##
## data:  tedv_exp$orbit_volume by tedv_exp$optic_neuropathy
## W = 100, p-value = 0.4
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test( tedv_exp$lagophthalmos ~tedv_exp$optic_neuropathy)
```

```
## Warning in wilcox.test.default(x = c(0, 2, 1, 0.5, 1, 2, 2, 0, 0, 0, 1, :
## cannot compute exact p-value with ties
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  tedv_exp$lagophthalmos by tedv_exp$optic_neuropathy
## W = 70, p-value = 0.5
## alternative hypothesis: true location shift is not equal to 0
```

```
#wilcox.test( tedv_exp$D ~tedv_exp$optic_neuropathy)
wilcox.test( tedv_exp$MV.FV ~tedv_exp$optic_neuropathy)
```

```
##
##  Wilcoxon rank sum test
##
## data:  tedv_exp$MV.FV by tedv_exp$optic_neuropathy
## W = 100, p-value = 0.06
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test( tedv_exp$medial_rectus_muscle_vol ~tedv_exp$optic_neuropathy)
```

```
## Warning in wilcox.test.default(x = c(1077.73, 949.66, 1529.42, 2602.97, :
## cannot compute exact p-value with ties
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  tedv_exp$medial_rectus_muscle_vol by tedv_exp$optic_neuropathy
## W = 20, p-value = 0.2
## alternative hypothesis: true location shift is not equal to 0
```

```
tedv_exp %>%  filter(optic_neuropathy==1) %>% summarise(mean(lagophthalmos, na.rm= T), mean(hertel, na.
```

```
##   mean(lagophthalmos, na.rm = T) mean(hertel, na.rm = T)
## 1                           0.79                      22
##   mean(FV.OV, na.rm = T) mean(MV.OV, na.rm = T)
## 1                     26                     51
##   mean(orbit_volume, na.rm = T) mean(MV.FV, na.rm = T)
## 1                         26109                   2.4
##   mean(medial_rectus_muscle_vol, na.rm = T)
## 1                                      2617
```

```
tedv_exp %>%  filter(optic_neuropathy==0) %>% summarise(mean(lagophthalmos, na.rm= T), mean(hertel, na.
```

```
##   mean(lagophthalmos, na.rm = T) mean(hertel, na.rm = T)
## 1                           0.54                      22
##   mean(FV.OV, na.rm = T) mean(MV.OV, na.rm = T)
## 1                     34                     48
##   mean(orbit_volume, na.rm = T) mean(MV.FV, na.rm = T)
## 1                         24464                   1.6
##   mean(medial_rectus_muscle_vol, na.rm = T)
## 1                                      1760
```

```
#Strabismus
wilcox.test( tedv_exp$lagophthalmos ~tedv_exp$Strabismus.0.No.1.yes)
```

```
## Warning in wilcox.test.default(x = c(0, 1, 0.5, 1, 0, 0, 1, 0, 2, 1, 1, :
## cannot compute exact p-value with ties
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  tedv_exp$lagophthalmos by tedv_exp$Strabismus.0.No.1.yes
## W = 200, p-value = 0.6
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test( tedv_exp$hertel ~tedv_exp$Strabismus.0.No.1.yes)
```

```
## Warning in wilcox.test.default(x = c(19, 24, 21.5, 22, 16, 28, 21, 21,
## 26, : cannot compute exact p-value with ties
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  tedv_exp$hertel by tedv_exp$Strabismus.0.No.1.yes
## W = 300, p-value = 0.4
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test( tedv_exp$fat_volume ~tedv_exp$Strabismus.0.No.1.yes)
```

```
##
##  Wilcoxon rank sum test
##
## data:  tedv_exp$fat_volume by tedv_exp$Strabismus.0.No.1.yes
## W = 300, p-value = 0.9
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test( tedv_exp$muscle_volume ~tedv_exp$Strabismus.0.No.1.yes)
```

```
##
##  Wilcoxon rank sum test
##
## data:  tedv_exp$muscle_volume by tedv_exp$Strabismus.0.No.1.yes
## W = 200, p-value = 0.3
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test( tedv_exp$orbit_volume ~tedv_exp$Strabismus.0.No.1.yes)
```

```
##
##  Wilcoxon rank sum test
##
## data:  tedv_exp$orbit_volume by tedv_exp$Strabismus.0.No.1.yes
## W = 300, p-value = 0.6
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test( tedv_exp$MV.FV ~tedv_exp$Strabismus.0.No.1.yes)# Significant
```

```
##
##  Wilcoxon rank sum test
##
## data:  tedv_exp$MV.FV by tedv_exp$Strabismus.0.No.1.yes
## W = 200, p-value = 0.2
## alternative hypothesis: true location shift is not equal to 0
```

```
tedv_exp %>%  filter(Strabismus.0.No.1.yes==1) %>% summarise(mean(lagophthalmos, na.rm= T), mean(hertel
```

```
##   mean(lagophthalmos, na.rm = T) mean(hertel, na.rm = T)
## 1                           0.56                      22
##   mean(FV.OV, na.rm = T) mean(MV.OV, na.rm = T)
## 1                     31                    50
##   mean(orbit_volume, na.rm = T) mean(MV.FV, na.rm = T)
## 1                         25043                     2
##   mean(medial_rectus_muscle_vol, na.rm = T)
## 1                                      1988
```

```
tedv_exp %>%  filter(Strabismus.0.No.1.yes==0) %>% summarise(mean(lagophthalmos, na.rm= T), mean(hertel
```

```
##   mean(lagophthalmos, na.rm = T) mean(hertel, na.rm = T)
## 1                           0.61                      23
##   mean(FV.OV, na.rm = T) mean(MV.OV, na.rm = T)
## 1                     35                    46
##   mean(orbit_volume, na.rm = T) mean(MV.FV, na.rm = T)
## 1                         24360                   1.5
##   mean(medial_rectus_muscle_vol, na.rm = T)
## 1                                      2732
```

```
#Decompression
wilcox.test( tedv_exp$lagophthalmos ~tedv_exp$decompression)
```

```
## Warning in wilcox.test.default(x = c(0, 0, 1, 0.5, 0, 0, 0, 0, 0, 0, 1, :
## cannot compute exact p-value with ties
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  tedv_exp$lagophthalmos by tedv_exp$decompression
## W = 100, p-value = 0.02
```

```
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test( tedv_exp$hertel ~tedv_exp$decompression)
```

```
## Warning in wilcox.test.default(x = c(22, 19, 24, 21.5, 21, 16, 21, 17,
## 28, : cannot compute exact p-value with ties
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  tedv_exp$hertel by tedv_exp$decompression
## W = 100, p-value = 0.2
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test( tedv_exp$FV.OV ~tedv_exp$decompression)
```

```
##
##  Wilcoxon rank sum test
##
## data:  tedv_exp$FV.OV by tedv_exp$decompression
## W = 100, p-value = 0.3
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test( tedv_exp$muscle_volume ~tedv_exp$decompression)
```

```
##
##  Wilcoxon rank sum test
##
## data:  tedv_exp$muscle_volume by tedv_exp$decompression
## W = 200, p-value = 0.8
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test( tedv_exp$orbit_volume ~tedv_exp$decompression)
```

```
##
##  Wilcoxon rank sum test
##
## data:  tedv_exp$orbit_volume by tedv_exp$decompression
## W = 100, p-value = 0.3
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test( tedv_exp$MV.FV~tedv_exp$decompression)#
```

```
##
##  Wilcoxon rank sum test
##
## data:  tedv_exp$MV.FV by tedv_exp$decompression
## W = 200, p-value = 0.9
## alternative hypothesis: true location shift is not equal to 0
```

```
#Decompression correlated to lagopthalmos, hertel, fat_volume, orbit_volume and not MV


tedv_exp %>%  filter(decompression==1) %>% summarise(mean(lagophthalmos, na.rm= T), mean(hertel, na.rm=
```

```
##   mean(lagophthalmos, na.rm = T) mean(hertel, na.rm = T)
## 1                           0.86                      23
##   mean(FV.OV, na.rm = T) mean(MV.OV, na.rm = T)
## 1                     36                    49
```

```
##   mean(orbit_volume, na.rm = T) mean(MV.FV, na.rm = T)
## 1                         25216                   1.8
##   mean(medial_rectus_muscle_vol, na.rm = T)
## 1                                      2367
```

```
tedv_exp %>%  filter(decompression==0) %>% summarise(mean(lagophthalmos, na.rm= T), mean(hertel, na.rm=
```

```
##   mean(lagophthalmos, na.rm = T) mean(hertel, na.rm = T)
## 1                           0.34                     21
##   mean(FV.OV, na.rm = T) mean(MV.OV, na.rm = T)
## 1                     32                    47
##   mean(orbit_volume, na.rm = T) mean(MV.FV, na.rm = T)
## 1                         24253                   1.6
##   mean(medial_rectus_muscle_vol, na.rm = T) n()
## 1                                      1108  22
```