Project Title

A STAT 139 Final Project

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Due December 13, 2017

Abstract

Introduction

- Obesity is an exerbating problem in the US.
- Explore the association of 21 different factors with weight, 13 of which are behavior-related factors such as the typical number of hours sleep per night

Methods

- Data description
- data source is NHANES 2013-2014
- Variables of interest
- Only consider adults of age 20 or above
- Data preprocessing & assumptions
- Merge data by participant sequence number
- Exclude don't know/refused/missing values — discuss implications in limitations
- Perform EDA
- Fit regression models
- Check assumptions

Results

Exploratory Data Analysis

Limitations

Conclusions

Appendix

Appendix I: Data preprocessing

```
library(dplyr)
```

```
## Warning: package 'dplyr' was built under R version 3.3.2
```

```
##
## 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
```

```
demographics = read.csv("data/health/demographic.csv")
ques = read.csv("data/health/questionnaire.csv")
exam = read.csv("data/health/examination.csv")

# join tables by participant ID
df = inner_join(demographics, ques, by="SEQN")
df = inner_join(df, exam, by="SEQN")
dim(df)
```

```
## [1] 9813 1222
```

```
# subset df to consider only the variables we're interested in
response = "BMXWT"
predictors = c("BMXHT", "RIAGENDR", "RIDAGEYR", "RIDRETH3", "DMDEDUC2", "DMDMARTL", "DMDFMSIZ", "IN
               "ALQ101", "ALQ120Q",
               "CBD070", "CBD120", "CBD130",
               "DBD895", "DBD900", "DBQ197",
               "DPQ020", "DPQ030",
               "PAQ710",
               "SLD010H", "SMQ040")

columns = c(predictors, response)

df = df[names(df) %in% columns]

# rename columns to more intuitive names
df = rename(df, height = BMXHT, gender = RIAGENDR, age = RIDAGEYR, race = RIDRETH3, edu = DMDEDUC2,
            marriage = DMDMARTL, famsize = DMDFMSIZ, famincome = INDFMIN2,
            alcohol12yr = ALQ101, alcoholfrq = ALQ120Q, grocery = CBD070, eatout = CBD120,
            delivery = CBD130, milk = DBQ197, meals_nothome = DBD895, meals_fastfood = DBD900,
            depressed = DPQ020, sleep_trouble = DPQ030, tv_hrs = PAQ710,
            sleep_hr = SLD010H, smoke = SMQ040, weight = BMXWT)

# subset the df to consider only adults aged 20 or above
df_adult = df[df$age > 20,]

# subset the data to exclude refused/don't know/missing data
# demographics variables
df_adult = df_adult[which(df_adult$edu!=7 & df_adult$edu!=9),]
```

```r
df_adult = df_adult[which(df_adult$marriage!=77 & df_adult$marriage!=99),]
df_adult = df_adult[which(df_adult$famincome!=77 & df_adult$famincome!=99),]

# alcohol use variables
df_adult = df_adult[which(df_adult$alcohol12yr!=7 & df_adult$alcohol12yr!=9),]
df_adult = df_adult[which(df_adult$alcoholfrq!=777 & df_adult$alcoholfrq!=999),]

# consumer behavior variables
df_adult = df_adult[which(df_adult$grocery!=777777 & df_adult$grocery!=999999),]
df_adult = df_adult[which(df_adult$eatout!=777777 & df_adult$eatout!=999999),]
df_adult = df_adult[which(df_adult$delivery!=777777 & df_adult$delivery!=999999),]

# diet behavior variables
df_adult = df_adult[which(df_adult$meals_nothome != 5555 & df_adult$meals_nothome != 7777 & df_adul
df_adult = df_adult[which(df_adult$meals_fastfood != 5555 & df_adult$meals_fastfood != 7777 & df_ad

# physical activity variables
df_adult$tv_hrs[which(df_adult$tv_hrs == 0)] = 1
df_adult$tv_hrs[which(df_adult$tv_hrs == 8)] = 0
df_adult = df_adult[which(df_adult$tv_hrs != 77 & df_adult$tv_hrs != 99),]

# mental health variables
df_adult = df_adult[which(df_adult$depressed!=7 & df_adult$depressed!=9),]
df_adult = df_adult[which(df_adult$sleep_trouble!=7 & df_adult$sleep_trouble!=9),]

# sleeping behavior variables
df_adult = df_adult[which(df_adult$sleep_hr != 99),]

# smoking behavior variables
df_adult$smoke[which(is.na(df_adult$smoke))] = "missing"

# after dropping observations missing weight, there were only 3 missing height
# so we drop these observations too
drop_obs = c("weight", "height")

for (feature in drop_obs){
  df_adult = df_adult[!is.na(df_adult[feature]),]
}

# save variable names into lists of categorical or numeric faetures
categorical_features = c("gender", "race", "edu", "marriage",
                         "famincome", "alcohol12yr", "milk", "depressed",
                         "sleep_trouble", "smoke", "tv_hrs")

numeric_features = c("height","age", "famsize", "alcoholfrq", "grocery", "eatout",
                     "delivery", "meals_nothome", "meals_fastfood", "sleep_hr")
```

```
# convert categorical variables into factors
df_adult[categorical_features] = lapply(df_adult[categorical_features], factor)

apply(df_adult, 2, function(x) sum(is.na(x))) # check how many missing data
```

```
##         gender            age           race            edu       marriage
##              0              0              0              0              0
##       famsize      famincome    alcohol12yr     alcoholfrq        grocery
##              0              0              0              0              0
##         eatout       delivery           milk  meals_nothome meals_fastfood
##              0              0              0              0              0
##      depressed  sleep_trouble         tv_hrs       sleep_hr          smoke
##              0              0              0              0              0
##         weight         height
##              0              0
```

```
sapply(df_adult, class) # check data classes
```

```
##         gender            age           race            edu       marriage
##       "factor"      "integer"       "factor"       "factor"       "factor"
##        famsize      famincome    alcohol12yr     alcoholfrq        grocery
##      "integer"       "factor"       "factor"      "integer"      "integer"
##         eatout       delivery           milk  meals_nothome meals_fastfood
##      "integer"      "integer"       "factor"      "integer"      "integer"
##      depressed  sleep_trouble         tv_hrs       sleep_hr          smoke
##       "factor"       "factor"       "factor"      "integer"       "factor"
##         weight         height
##      "numeric"      "numeric"
```

Appendix II: Exploratory Data Analysis

Response Variable (Weight)

```
library(ggplot2)
require(gridExtra)
```

```
## Loading required package: gridExtra
```

```
##
## Attaching package: 'gridExtra'
```

```
## The following object is masked from 'package:dplyr':
##
##     combine
```

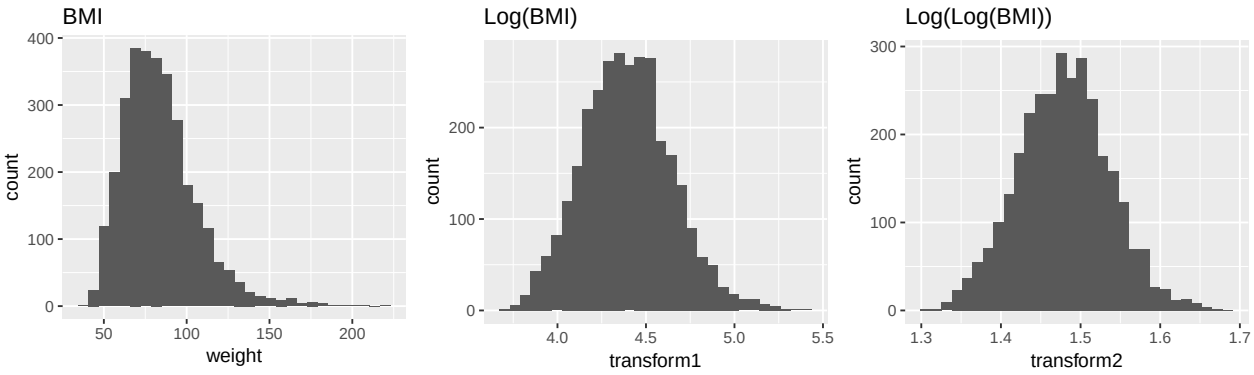
```
transform1 = log(df_adult$weight)
transform2 = log(log(df_adult$weight))

# response variable distribution
plot1 = ggplot(df_adult, aes(weight)) +
```

```
  geom_histogram() +
  ggtitle("BMI")
plot2 = ggplot(df_adult, aes(transform1)) +
  geom_histogram() +
  ggtitle("Log(BMI)")
plot3 = ggplot(df_adult, aes(transform2)) +
  geom_histogram() +
  ggtitle("Log(Log(BMI))")
grid.arrange(plot1, plot2, plot3, ncol=3)
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

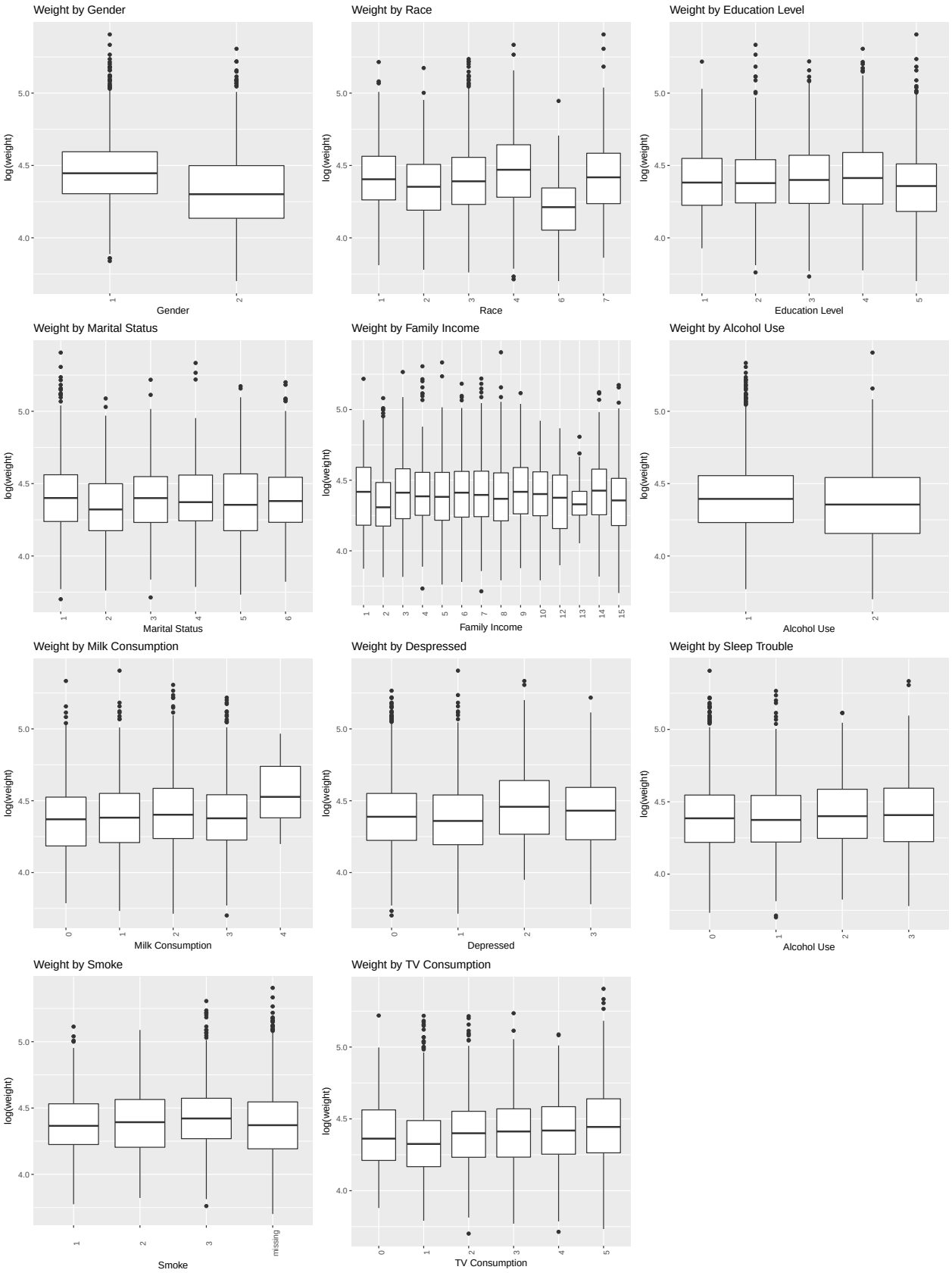


Predictor Variables

Categorical Variables

```
plot1 = ggplot(df_adult, aes(x=gender, y = log(weight))) + geom_boxplot() +
  theme(axis.text.x = element_text(angle=90)) +
  labs(x="Gender", y="log(weight)") +
  ggtitle("Weight by Gender")
plot2 = ggplot(df_adult, aes(x=race, y = log(weight))) + geom_boxplot() +
  theme(axis.text.x = element_text(angle=90)) +
  labs(x="Race", y="log(weight)") +
  ggtitle("Weight by Race")
plot3 = ggplot(df_adult, aes(x=edu, y = log(weight))) + geom_boxplot() +
  theme(axis.text.x = element_text(angle=90)) +
  labs(x="Education Level", y="log(weight)") +
  ggtitle("Weight by Education Level")
plot4 = ggplot(df_adult, aes(x=marriage, y = log(weight))) + geom_boxplot() +
  theme(axis.text.x = element_text(angle=90)) +
  labs(x="Marital Status", y="log(weight)") +
  ggtitle("Weight by Marital Status")
```

```
plot5 = ggplot(df_adult, aes(x=famincome, y = log(weight))) + geom_boxplot() +
  theme(axis.text.x = element_text(angle=90)) +
  labs(x="Family Income", y="log(weight)") +
  ggtitle("Weight by Family Income")
plot6 = ggplot(df_adult, aes(x=alcohol12yr, y = log(weight))) + geom_boxplot() +
  theme(axis.text.x = element_text(angle=90)) +
  labs(x="Alcohol Use", y="log(weight)") +
  ggtitle("Weight by Alcohol Use")
plot7 = ggplot(df_adult, aes(x=milk, y = log(weight))) + geom_boxplot() +
  theme(axis.text.x = element_text(angle=90)) +
  labs(x="Milk Consumption", y="log(weight)") +
  ggtitle("Weight by Milk Consumption")
plot8 = ggplot(df_adult, aes(x=depressed, y = log(weight))) + geom_boxplot() +
  theme(axis.text.x = element_text(angle=90)) +
  labs(x="Depressed", y="log(weight)") +
  ggtitle("Weight by Despressed")
plot9 = ggplot(df_adult, aes(x=sleep_trouble, y = log(weight))) + geom_boxplot() +
  theme(axis.text.x = element_text(angle=90)) +
  labs(x="Alcohol Use", y="log(weight)") +
  ggtitle("Weight by Sleep Trouble")
plot10 = ggplot(df_adult, aes(x=smoke, y = log(weight))) + geom_boxplot() +
  theme(axis.text.x = element_text(angle=90)) +
  labs(x="Smoke", y="log(weight)") +
  ggtitle("Weight by Smoke")
plot11 = ggplot(df_adult, aes(x=tv_hrs, y = log(weight))) + geom_boxplot() +
  theme(axis.text.x = element_text(angle=90)) +
  labs(x="TV Consumption", y="log(weight)") +
  ggtitle("Weight by TV Consumption")
grid.arrange(plot1, plot2, plot3, plot4, plot5, plot6, plot7, plot8, plot9, plot10, plot11, ncol=3)
```


Weight by Gender
log(weight)
Gender
Weight by Race
Race
Weight by Education Level
Education Level
Weight by Marital Status
Marital Status
Weight by Family Income
Family Income
Weight by Alcohol Use
Alcohol Use
Weight by Milk Consumption
Milk Consumption
Weight by Despressed
Depressed
Weight by Sleep Trouble
Alcohol Use
Weight by Smoke
Smoke
Weight by TV Consumption
TV Consumption

Numeric Variables

Distribtuion of numeric variables

```
# numeric predictor variable distributions
plot1 = ggplot(df_adult, aes(age)) + geom_histogram() +
  ggtitle("Age")
plot2 = ggplot(df_adult, aes(height)) + geom_histogram() +
  ggtitle("Height")
plot3 = ggplot(df_adult, aes(famsize)) + geom_histogram() +
  ggtitle("Family Size")
plot4 = ggplot(df_adult, aes(alcoholfrq)) + geom_histogram() +
  ggtitle("Frequency of Alcohol Consumption")
plot5 = ggplot(df_adult, aes(grocery)) + geom_histogram() +
  ggtitle("Money Spent on Grocery")
plot6 = ggplot(df_adult, aes(eatout)) + geom_histogram() +
  ggtitle("Money Spent Eating Out")
plot7 = ggplot(df_adult, aes(delivery)) + geom_histogram() +
  ggtitle("Money Spent on Delivered Food")
plot8 = ggplot(df_adult, aes(meals_nothome)) + geom_histogram() +
  ggtitle("Number of Meals Not Home Prepared")
plot9 = ggplot(df_adult, aes(meals_fastfood)) + geom_histogram() +
  ggtitle("Number of Fast Food Meals")
plot10 = ggplot(df_adult, aes(sleep_hr)) + geom_histogram() +
  ggtitle("Hours of Sleep")
grid.arrange(plot1, plot2, plot3, plot4, plot5, plot6, plot7, plot8, plot9, plot10, ncol=3)
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
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```

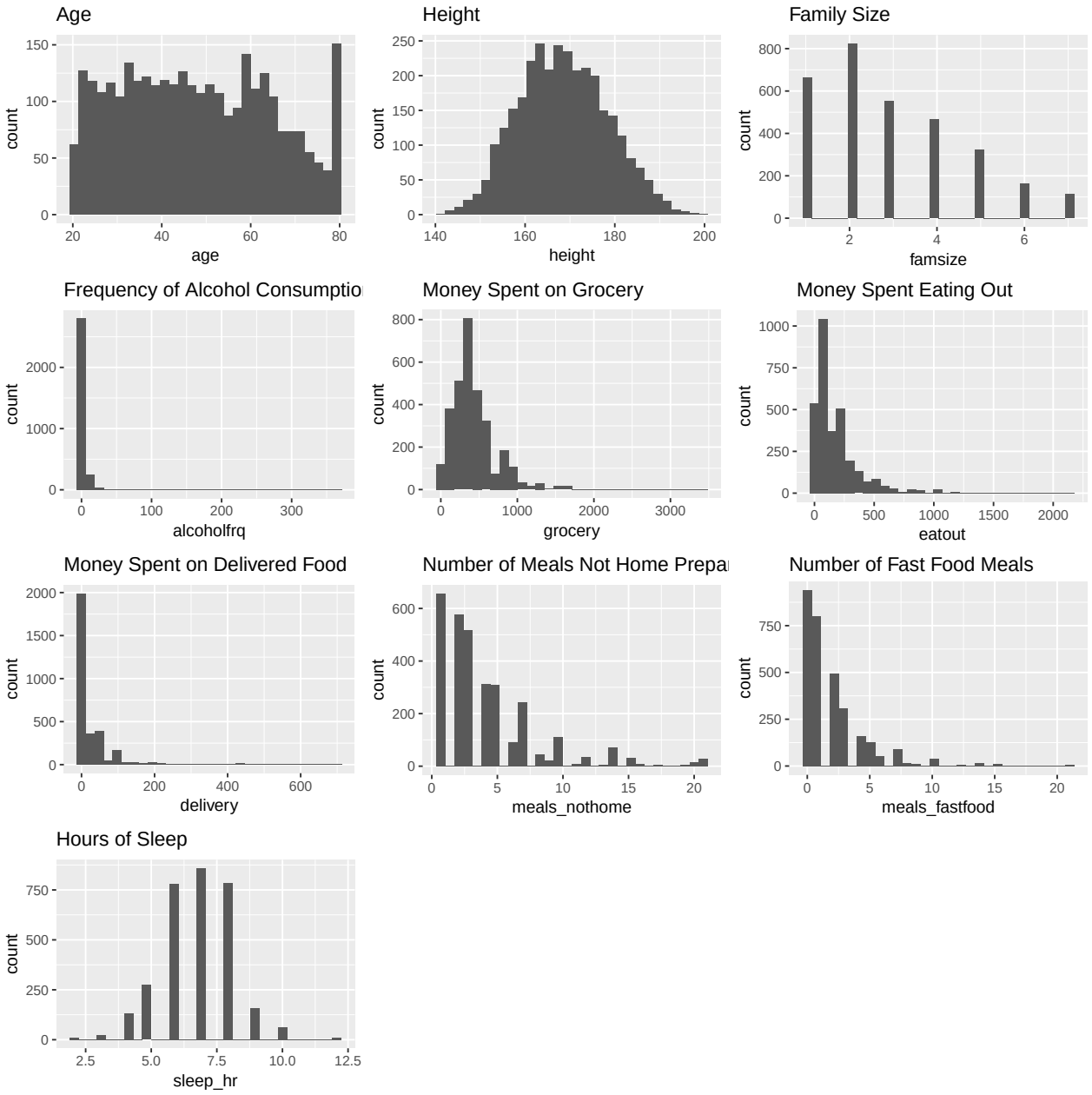


```
# transformations on numeric predictor variables
plot1 = ggplot(df_adult, aes(alcoholfrq)) + geom_histogram() +
  ggtitle("Frequency of Alcohol Consumption")
plot2 = ggplot(df_adult, aes(log(alcoholfrq)+1)) + geom_histogram() +
  ggtitle("Log Frequency of Alcohol Consumption")

plot3 = ggplot(df_adult, aes(grocery)) + geom_histogram() +
  ggtitle("Money Spent on Grocery")
plot4 = ggplot(df_adult, aes(log(grocery)+1)) + geom_histogram() +
  ggtitle("Log Money Spent on Grocery")

plot5 = ggplot(df_adult, aes(eatout)) + geom_histogram() +
```

```r
  ggtitle("Money Spent on Eating Out")
plot6 = ggplot(df_adult, aes(log(eatout)+1)) + geom_histogram() +
  ggtitle("Log Money Spent on Eating Out")

plot7 = ggplot(df_adult, aes(delivery)) + geom_histogram() +
  ggtitle("Money Spent on Delivered Food")
plot8 = ggplot(df_adult, aes(log(delivery)+1)) + geom_histogram() +
  ggtitle("Log Money Spent on Delivered Food")

plot9 = ggplot(df_adult, aes(meals_nothome)) + geom_histogram() +
  ggtitle("Number of Meals Not Home Prepared")
plot10 = ggplot(df_adult, aes(log(meals_nothome)+1)) + geom_histogram() +
  ggtitle("Log Number of Meals Not Home Prepared")

plot11 = ggplot(df_adult, aes(meals_fastfood)) + geom_histogram() +
  ggtitle("Number of Fast Food Meals")
plot12 = ggplot(df_adult, aes(log(meals_fastfood)+1)) + geom_histogram() +
  ggtitle("Log Number of Fast Food Meals")
grid.arrange(plot1, plot2, plot3, plot4, plot5, plot6, plot7, plot8, plot9, plot10, plot11, plot12,
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
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## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```
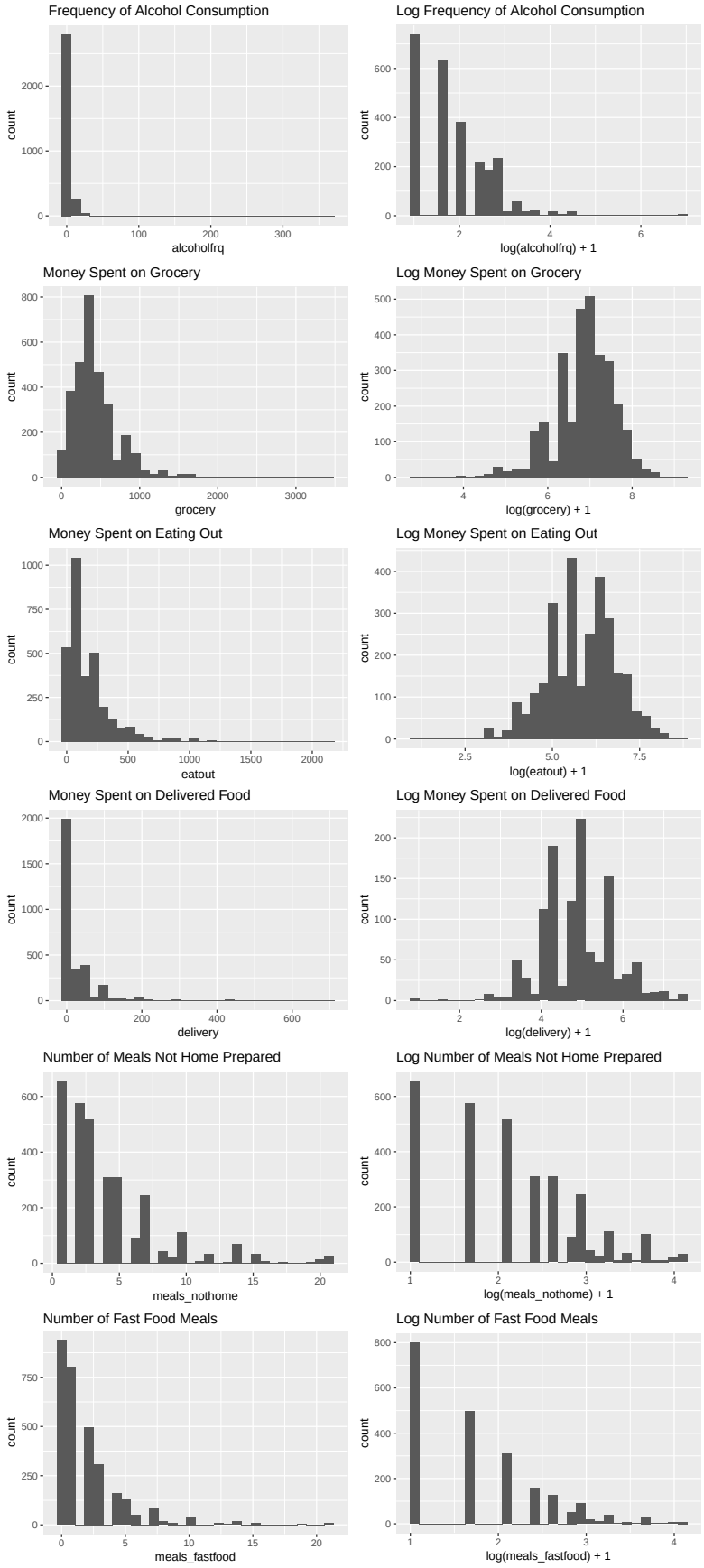
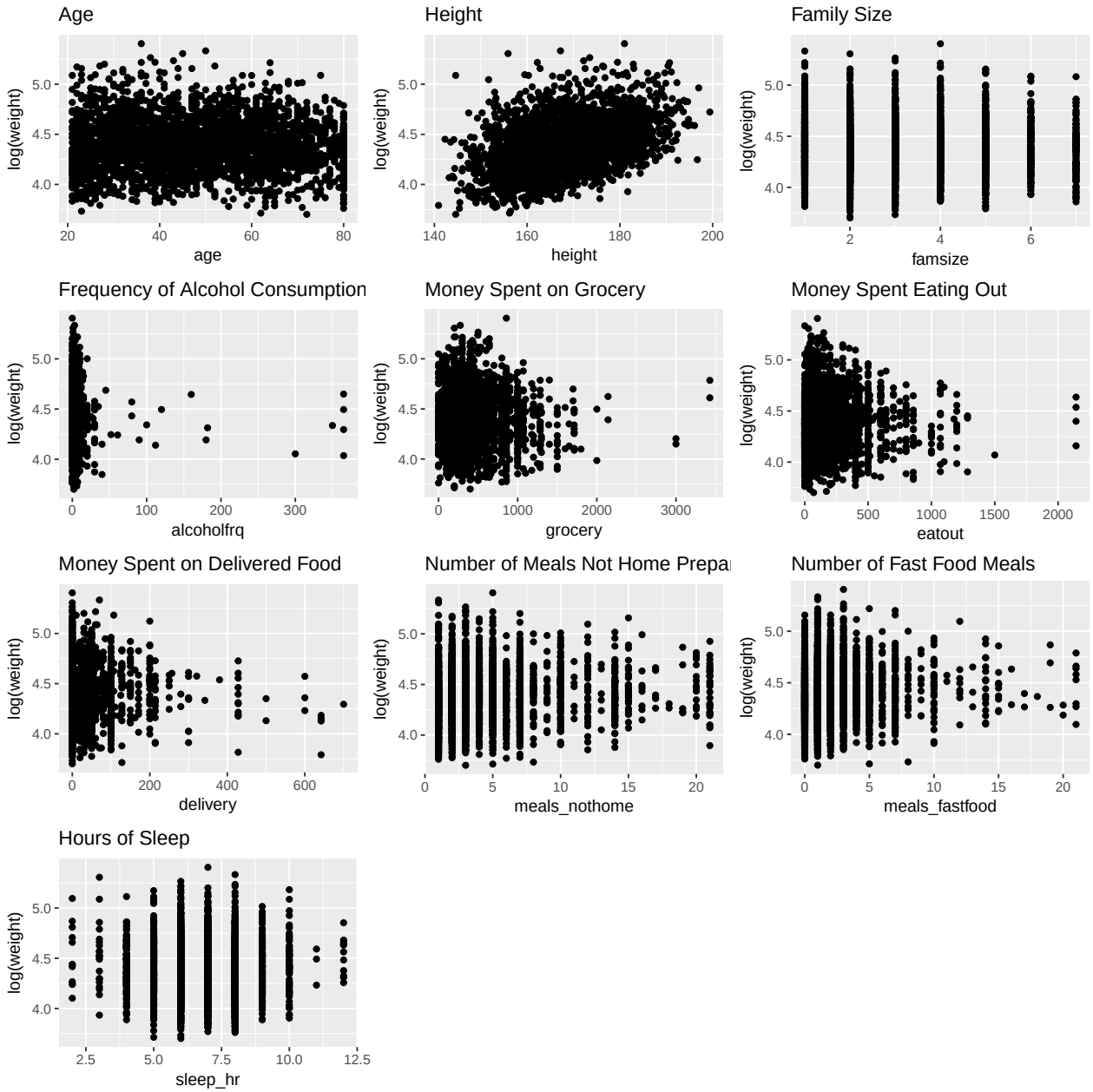


Frequency of Alcohol Consumption
count
alcoholfrq
Log Frequency of Alcohol Consumption
count
log(alcoholfrq) + 1
Money Spent on Grocery
count
grocery
Log Money Spent on Grocery
count
log(grocery) + 1
Money Spent on Eating Out
count
eatout
Log Money Spent on Eating Out
count
log(eatout) + 1
Money Spent on Delivered Food
count
delivery
Log Money Spent on Delivered Food
count
log(delivery) + 1
Number of Meals Not Home Prepared
count
meals_nothome
Log Number of Meals Not Home Prepared
count
log(meals_nothome) + 1
Number of Fast Food Meals
count
meals_fastfood
Log Number of Fast Food Meals
count
log(meals_fastfood) + 1

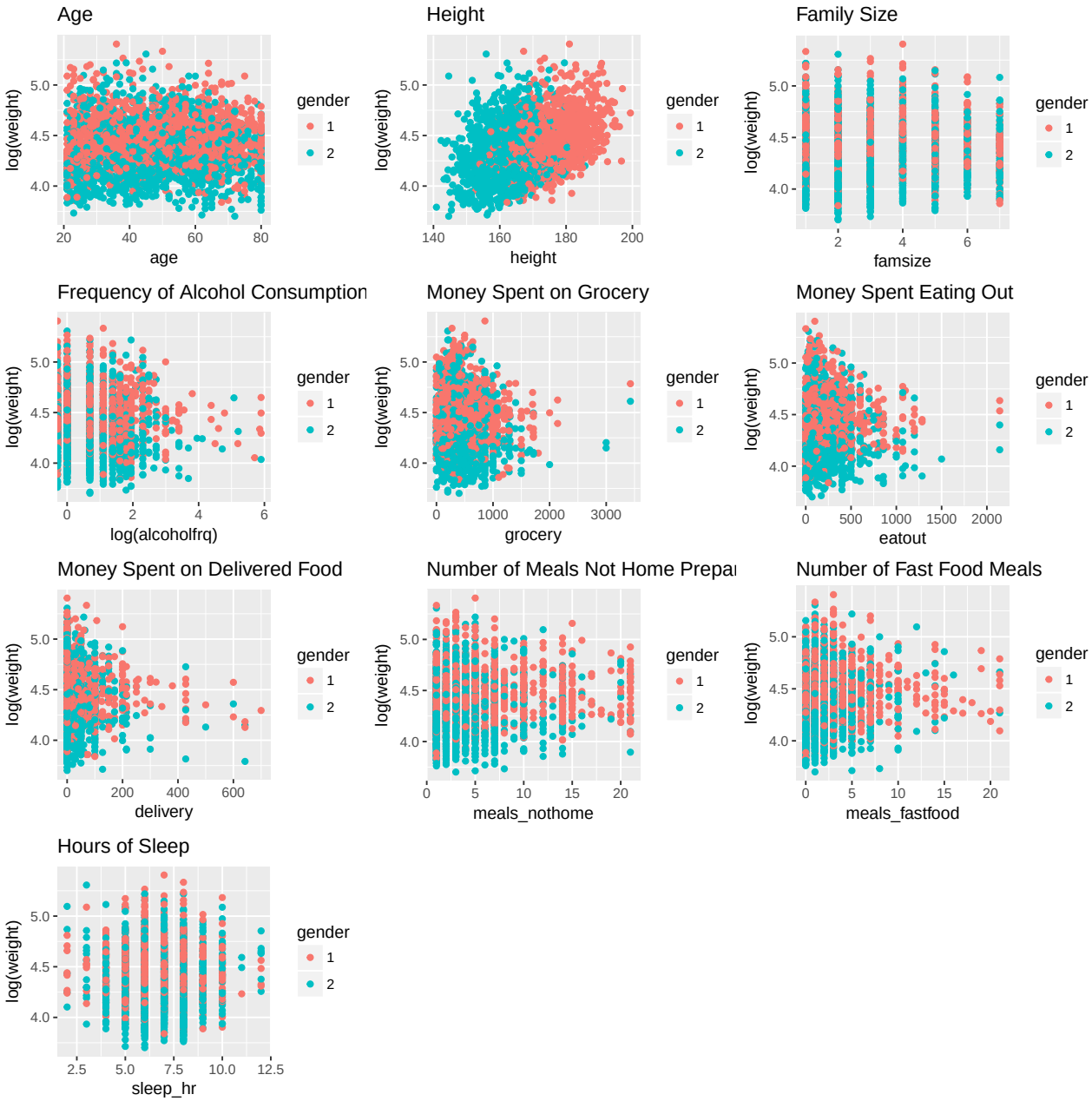
Response vs. numeric distribution

```
plot1 = ggplot(df_adult, aes(x=age, y=log(weight))) + geom_point() +
  ggtitle("Age")
plot2 = ggplot(df_adult, aes(x=height, y=log(weight))) + geom_point() +
  ggtitle("Height")
plot3 = ggplot(df_adult, aes(x=famsize, y=log(weight))) + geom_point() +
  ggtitle("Family Size")
plot4 = ggplot(df_adult, aes(x=alcoholfrq, y=log(weight))) + geom_point() +
  ggtitle("Frequency of Alcohol Consumption")
plot5 = ggplot(df_adult, aes(x=grocery, y=log(weight))) + geom_point() +
  ggtitle("Money Spent on Grocery")
plot6 =ggplot(df_adult, aes(x=eatout, y=log(weight))) + geom_point() +
  ggtitle("Money Spent Eating Out")
plot7 = ggplot(df_adult, aes(x=delivery, y=log(weight))) + geom_point() +
  ggtitle("Money Spent on Delivered Food")
plot8 =ggplot(df_adult, aes(x=meals_nothome, y=log(weight))) + geom_point() +
  ggtitle("Number of Meals Not Home Prepared")
plot9 = ggplot(df_adult, aes(x=meals_fastfood, y=log(weight))) + geom_point() +
  ggtitle("Number of Fast Food Meals")
plot10 = ggplot(df_adult, aes(x=sleep_hr, y=log(weight))) + geom_point() +
  ggtitle("Hours of Sleep")
grid.arrange(plot1, plot2, plot3, plot4, plot5, plot6, plot7, plot8, plot9, plot10, ncol=3)
```




```
plot1 = ggplot(df_adult, aes(x=age, y=log(weight), colour=gender)) + geom_point() +
  ggtitle("Age")
plot2 = ggplot(df_adult, aes(x=height, y=log(weight), colour=gender)) + geom_point() +
  ggtitle("Height")
plot3 = ggplot(df_adult, aes(x=famsize, y=log(weight), colour=gender)) + geom_point() +
  ggtitle("Family Size")
plot4 = ggplot(df_adult, aes(x=log(alcoholfrq), y=log(weight), colour=gender)) + geom_point() +
  ggtitle("Frequency of Alcohol Consumption")
plot5 = ggplot(df_adult, aes(x=grocery, y=log(weight), colour=gender)) + geom_point() +
  ggtitle("Money Spent on Grocery")
plot6 =ggplot(df_adult, aes(x=eatout, y=log(weight), colour=gender)) + geom_point() +
  ggtitle("Money Spent Eating Out")
```

```
plot7 = ggplot(df_adult, aes(x=delivery, y=log(weight), colour=gender)) + geom_point() +
  ggtitle("Money Spent on Delivered Food")
plot8 =ggplot(df_adult, aes(x=meals_nothome, y=log(weight), colour=gender)) + geom_point() +
  ggtitle("Number of Meals Not Home Prepared")
plot9 = ggplot(df_adult, aes(x=meals_fastfood, y=log(weight), colour=gender)) + geom_point() +
  ggtitle("Number of Fast Food Meals")
plot10 = ggplot(df_adult, aes(x=sleep_hr, y=log(weight), colour=gender)) + geom_point() +
  ggtitle("Hours of Sleep")
grid.arrange(plot1, plot2, plot3, plot4, plot5, plot6, plot7, plot8, plot9, plot10, ncol=3)
```



```r
# response
df_adult$log.weight = log(df_adult$weight)

# numeric predictors
df_adult$log.alcoholfrq = log(df_adult$alcoholfrq + 1)
df_adult$log.grocery = log(df_adult$grocery + 1)
df_adult$log.eatout = log(df_adult$eatout + 1)
df_adult$log.delivery = log(df_adult$delivery + 1)
df_adult$log.nothome = log(df_adult$meals_nothome + 1)
df_adult$log.fastfood = log(df_adult$meals_fastfood + 1)
```

parallel corrd plot to figure out if interaction may be helpful

```r
# library(MASS)
# library(RColorBrewer)
# k <- adjustcolor(brewer.pal(5, "Set2")[df_adult$sleep_trouble], alpha=.6)
# predictor = c("sleep_hr", "age", "log.delivery", "meals_nothome", "meals_fastfood")
# parcoord(df_adult[,predictor], col=k)
```