```r
sum(nhanes$modvigmin==0)/nrow(nhanes)
```

```
## [1] 0.07841659
```

```r
sum(nhanes$vigmin==0)/nrow(nhanes)
```

```
## [1] 0.8801602
```

```r
sum(nhanes$lightmin==0)/nrow(nhanes)
```

```
## [1] 0
```

```r
#no diff in modmin by day really except 7th
nhanes %>% group_by(rep) %>% summarise(m=mean(modvigmin),s=sd(modmin)/sqrt(length(modmin)))
```

```
## # A tibble: 7  3
##     rep        m         s
##   <int>    <dbl>     <dbl>
## 1     1 22.60066 0.3411052
## 2     2 23.01777 0.3518468
## 3     3 22.96771 0.3583861
## 4     4 22.41386 0.3488521
## 5     5 22.24356 0.3589189
## 6     6 21.15523 0.3571320
## 7     7 19.41996 0.3616865
```

```r
#no diff in modmin by day really except 7th and 2nd
nhanes %>% group_by(rep) %>% summarise(m=mean(lightmin),s=sd(lightmin)/sqrt(length(lightmin)))
```

```
## # A tibble: 7  3
##     rep        m        s
##   <int>    <dbl>    <dbl>
```

```
## 1     1 258.6827 1.048918
## 2     2 261.5339 1.093391
## 3     3 258.6147 1.096388
## 4     4 258.8213 1.136550
## 5     5 258.2212 1.160056
## 6     6 255.2295 1.186014
## 7     7 244.4119 1.253172
```

```
#mondays most vig, fri-sun least, tues-thurs similar
nhanes %>% group_by(rep) %>% summarise(m=mean(vigmin),s=sd(vigmin)/sqrt(length(lightmin)))
```

```
## # A tibble: 7  3
##     rep         m          s
##   <int>     <dbl>      <dbl>
## 1     1 0.9411853 0.06110670
## 2     2 0.8115414 0.05276647
## 3     3 0.8965840 0.06021138
## 4     4 0.7660865 0.05689883
## 5     5 0.7392597 0.05397894
## 6     6 0.8310108 0.06361269
## 7     7 0.6902050 0.06106663
```

```
anova(lm(modvigmin~as.factor(rep),data=subset(nhanes,rep<6))) #first 5 days are similar, last t
```

```
## Analysis of Variance Table
##
## Response: modvigmin
##                   Df   Sum Sq Mean Sq F value Pr(>F)
## as.factor(rep)     4     2902  725.44  0.8288 0.5065
## Residuals      31937 27954416  875.30
```

```
#weekends lower
nhanes %>% group_by(dow) %>% summarise(m=mean(modvigmin),s=sd(modvigmin)/sqrt(length(modvigmin)
```

```
## # A tibble: 7  3
##     dow        m         s
##   <int>    <dbl>     <dbl>
## 1     1 17.46672 0.3539009
## 2     2 23.63394 0.3753241
## 3     3 23.49455 0.3683897
## 4     4 23.63173 0.3842220
## 5     5 23.18340 0.3712310
## 6     6 22.43408 0.3639320
## 7     7 19.52794 0.3799264
```

```
#weekends and thursday lower, friday higher
nhanes %>% group_by(dow) %>% summarise(m=mean(lightmin),s=sd(lightmin)/sqrt(length(lightmin)))
```

```
## # A tibble: 7  3
##     dow        m        s
##   <int>    <dbl>    <dbl>
## 1     1 239.7397 1.171315
## 2     2 259.8399 1.106457
## 3     3 260.0095 1.095333
## 4     4 259.8370 1.102353
## 5     5 256.6507 1.103868
## 6     6 263.0100 1.146749
## 7     7 256.8055 1.218114
```

```
#first day vig
nhanes %>% group_by(dow) %>% summarise(m=mean(vigmin),s=sd(vigmin)/sqrt(length(lightmin)))
```

```
## # A tibble: 7  3
```

```
##     dow         m          s
##   <int>     <dbl>      <dbl>
## 1     1 0.7239862 0.06502960
## 2     2 0.9462687 0.06184397
## 3     3 0.8742129 0.05357820
## 4     4 0.8859250 0.06278267
## 5     5 0.8446359 0.05683506
## 6     6 0.7264334 0.05487292
## 7     7 0.6707994 0.05419137
```

```
anova(lm(modvigmin~as.factor(dow),data=subset(nhanes,dow%in%c(2:6)))) #M-F similar
```

```
## Analysis of Variance Table
##
## Response: modvigmin
##                   Df   Sum Sq Mean Sq F value Pr(>F)
## as.factor(dow)     4     6363 1590.75  1.7992 0.1259
## Residuals      31803 28118692  884.15
```

```
#test for weekend effects
anova(lm(modvigmin ~ as.factor(weekend),data=nhanes))
```

```
## Analysis of Variance Table
##
## Response: modvigmin
##                       Df   Sum Sq Mean Sq F value    Pr(>F)
## as.factor(weekend)     1   181096  181096  214.83 < 2.2e-16 ***
## Residuals          42438 35773439     843
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(lm(lightmin ~ as.factor(weekend),data=nhanes))
```

```
## Analysis of Variance Table
##
## Response: lightmin
##                        Df    Sum Sq Mean Sq F value    Pr(>F)
## as.factor(weekend)      1   1042016 1042016  133.48 < 2.2e-16 ***
## Residuals           42438 331295573    7807
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

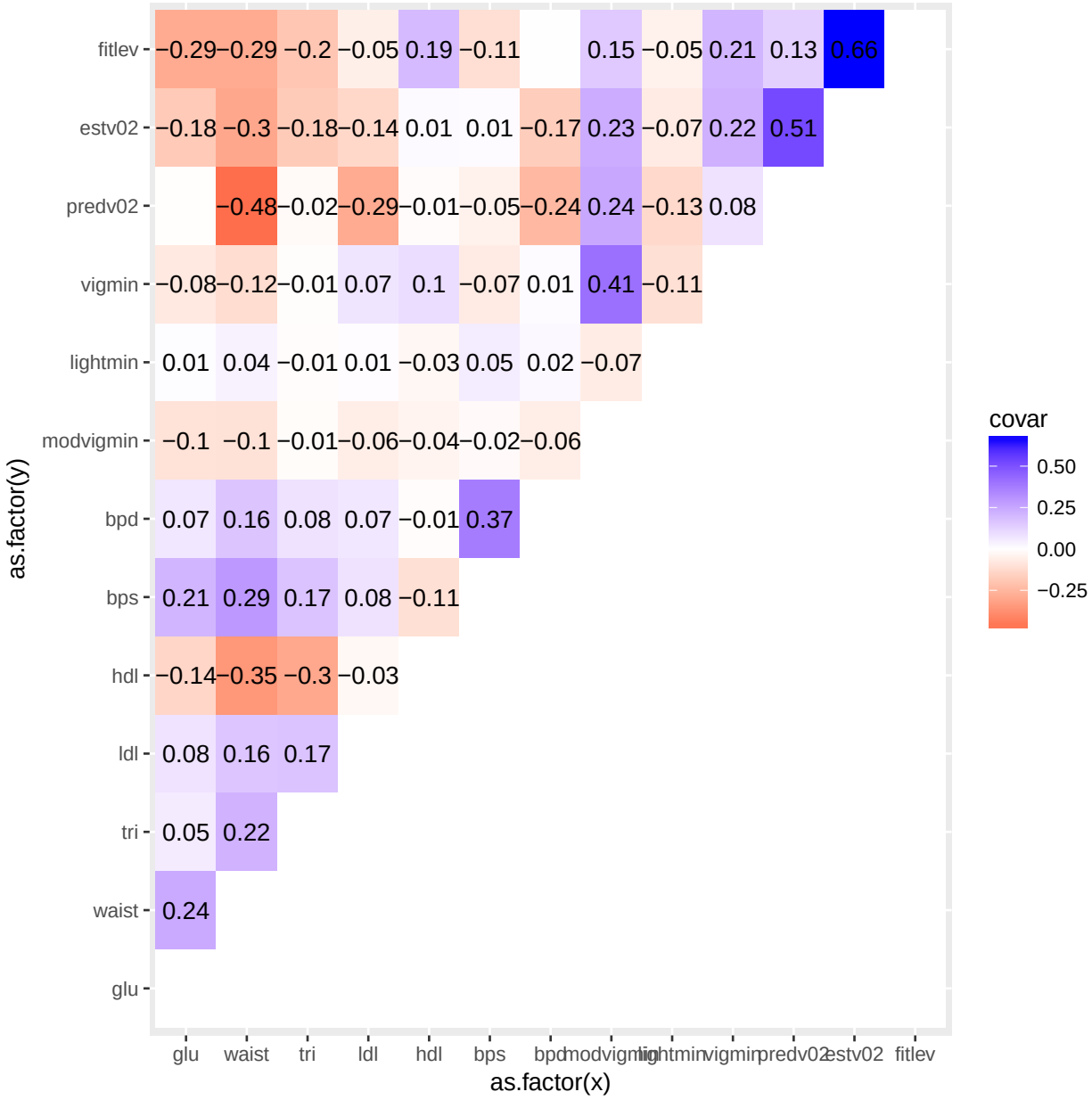
```
anova(lm(vigmin ~ as.factor(weekend),data=nhanes))
```

```
## Analysis of Variance Table
##
## Response: vigmin
##                        Df Sum Sq Mean Sq F value  Pr(>F)
## as.factor(weekend)      1    202 202.477   9.714 0.00183 **
## Residuals           42438 884572  20.844
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
nrep <- (nhanes %>% group_by(id) %>% summarise(n=length(id)))$n

#m1 <- lme(modvigmin~1,data=nhanes,random=~1|id,correlation=corAR1(form=~1|id),method="ML")
m1 <- lme(modvigmin~as.factor(rep)+as.factor(dow),data=nhanes,random=~1|id,method="ML")

re <- rep(unlist(ranef(m1)),nrep)
nhanes$error <- nhanes$modvigmin  - predict(m1)
eht <- nhanes %>% group_by(id) %>% summarise(e1=error[1],e2=error[2],e3=error[3],e4=error[4],e5

# ind <- which(!is.na(eht$e7))
# boxtest <- rep(0,length(ind))
```

```r
# for(i in 1:length(ind)){
#   boxtest[i] <- Box.test(unlist(eht[ind[i],-1]),lag=2,type="Ljung-Box")$p.value
# }
# summary(boxtest)

#lag 1 difference
o1a = c(eht$e1[nrep > 1],eht$e2[nrep > 2],eht$e3[nrep > 3],eht$e4[nrep > 4],eht$e5[nrep > 5],eh
o1b = c(eht$e2[nrep > 1],eht$e3[nrep > 2],eht$e4[nrep > 3],eht$e5[nrep > 4],eht$e6[nrep > 5],eh
cor(o1a,o1b)

## [1] -0.1000537

#lag 2 diff
o2a = c(eht$e1[nrep > 2],eht$e2[nrep > 3],eht$e3[nrep > 4],eht$e4[nrep > 5],eht$e5[nrep > 6])
o2b = c(eht$e3[nrep > 2],eht$e4[nrep > 3],eht$e5[nrep > 4],eht$e6[nrep > 5],eht$e7[nrep > 6])
cor(o2a,o2b)

## [1] -0.1892647

#lag 3 diff
o3a = c(eht$e1[nrep > 3],eht$e2[nrep > 4],eht$e3[nrep > 5],eht$e4[nrep > 6])
o3b = c(eht$e4[nrep > 3],eht$e5[nrep > 4],eht$e6[nrep > 5],eht$e7[nrep > 6])
cor(o3a,o3b)

## [1] -0.2558842

#lag 4 diff
o4a = c(eht$e1[nrep > 4],eht$e2[nrep > 5],eht$e3[nrep > 6])
o4b = c(eht$e5[nrep > 4],eht$e6[nrep > 5],eht$e7[nrep > 6])
cor(o4a,o4b)

## [1] -0.2653008
```

```
#lag 5 diff
o5a = c(eht$e1[nrep > 5],eht$e2[nrep > 6])
o5b = c(eht$e6[nrep > 5],eht$e7[nrep > 6])
cor(o5a,o5b)

## [1] -0.1862721
```



```r
#multivariate regression on mean observed modvig, light
a <- nhanes %>% group_by(id) %>% summarise(modvig=mean(modvigmin),light=mean(lightmin))
y$modvig <- a$modvig
y$light <- a$light

m3 <- lm(with(y,cbind(glu,waist,tri,hdl,bps,bpd))~y$modvig)
summary(m3)

## Response glu :
##
## Call:
## lm(formula = glu ~ y$modvig)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -62.50 -14.31  -6.71   2.63 440.78
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 107.87227    0.74640 144.524   <2e-16 ***
## y$modvig     -0.18519    0.02181  -8.491   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 32.92 on 3574 degrees of freedom
##   (4668 observations deleted due to missingness)
## Multiple R-squared:  0.01977,Adjusted R-squared:  0.0195
## F-statistic:  72.1 on 1 and 3574 DF,  p-value: < 2.2e-16
##
##
## Response waist :
```

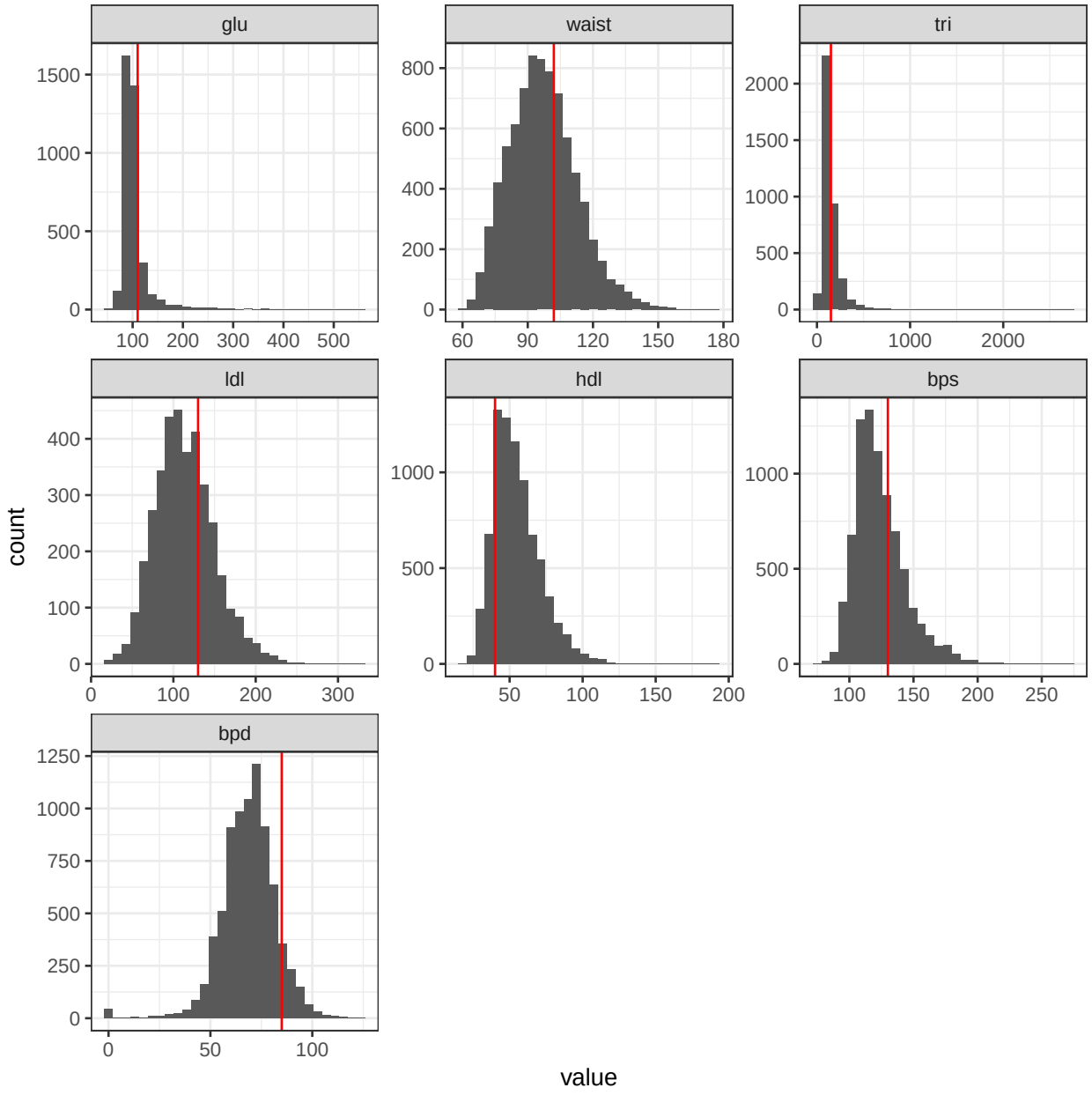
```
##
## Call:
## lm(formula = waist ~ y$modvig)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -37.507 -10.795  -1.156   9.475  58.162
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 100.19115    0.34288  292.20   <2e-16 ***
## y$modvig     -0.12379    0.01002  -12.36   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 15.12 on 3574 degrees of freedom
##   (4668 observations deleted due to missingness)
## Multiple R-squared:  0.04096,Adjusted R-squared:  0.0407
## F-statistic: 152.7 on 1 and 3574 DF,  p-value: < 2.2e-16
##
##
## Response tri :
##
## Call:
## lm(formula = tri ~ y$modvig)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -121.18  -65.00  -30.59   27.40 2585.85
##
## Coefficients:
```

```
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 154.32305    2.85134  54.123  < 2e-16 ***
## y$modvig     -0.40685    0.08331  -4.883 1.09e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 125.7 on 3574 degrees of freedom
##   (4668 observations deleted due to missingness)
## Multiple R-squared:  0.006628,Adjusted R-squared:  0.00635
## F-statistic: 23.85 on 1 and 3574 DF,  p-value: 1.089e-06
##
##
## Response hdl :
##
## Call:
## lm(formula = hdl ~ y$modvig)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -38.675 -11.922  -2.698   9.320 132.359
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  55.6949     0.3695 150.740   <2e-16 ***
## y$modvig     -0.0233     0.0108  -2.158    0.031 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 16.29 on 3574 degrees of freedom
##   (4668 observations deleted due to missingness)
## Multiple R-squared:  0.001302,Adjusted R-squared:  0.001022
```

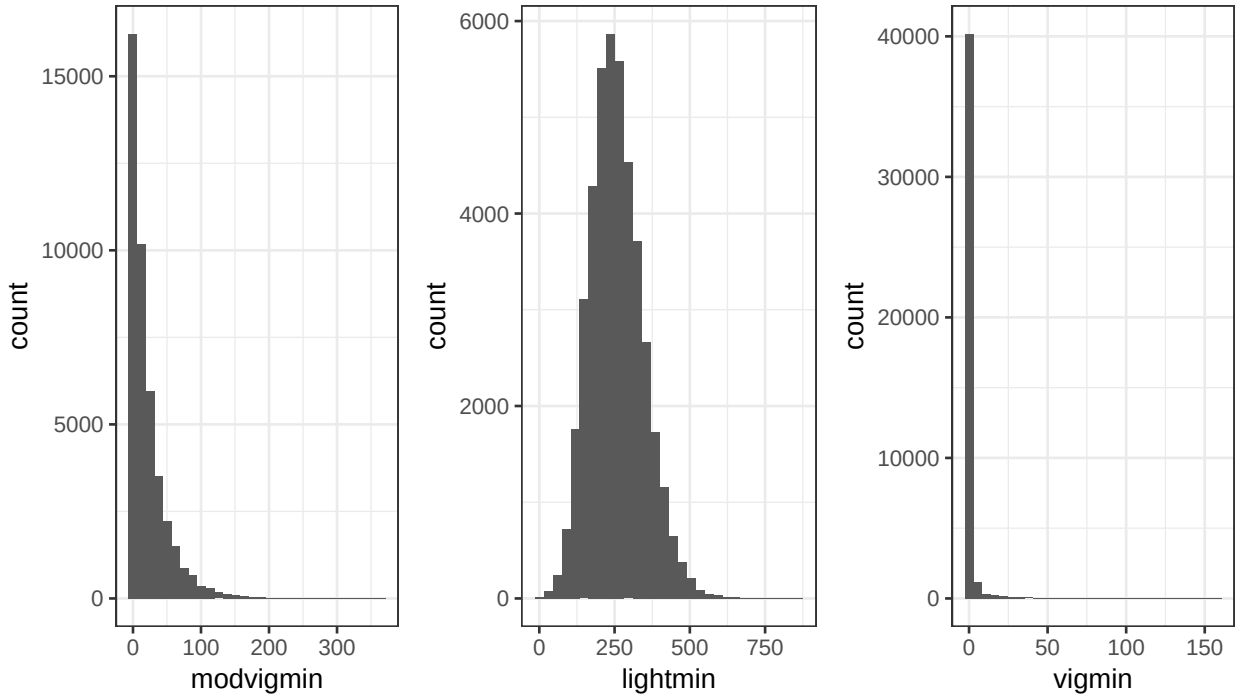
```
## F-statistic: 4.658 on 1 and 3574 DF,  p-value: 0.03097
##
##
## Response bps :
##
## Call:
## lm(formula = bps ~ y$modvig)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -44.510 -13.122  -2.921  10.172  93.694
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 126.33975    0.43377  291.26   <2e-16 ***
## y$modvig     -0.13340    0.01267  -10.53   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 19.13 on 3574 degrees of freedom
##   (4668 observations deleted due to missingness)
## Multiple R-squared:  0.03006,Adjusted R-squared:  0.02979
## F-statistic: 110.8 on 1 and 3574 DF,  p-value: < 2.2e-16
##
##
## Response bpd :
##
## Call:
## lm(formula = bpd ~ y$modvig)
##
## Residuals:
```

```
##     Min      1Q  Median      3Q     Max
## -68.064  -7.423   0.529   8.164  47.533
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 67.729506   0.310267 218.294   <2e-16 ***
## y$modvig     0.013836   0.009066   1.526    0.127
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 13.68 on 3574 degrees of freedom
##   (4668 observations deleted due to missingness)
## Multiple R-squared:  0.0006513,Adjusted R-squared:  0.0003717
## F-statistic: 2.329 on 1 and 3574 DF,  p-value: 0.1271
```

```
## Using  as id variables

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

## Warning:  Removed 14799 rows containing non-finite values (stat_bin).
```




```
## `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`.
```




```
summary(lm(wearmin~as.factor(dow),data=nhanes))


##
## Call:
## lm(formula = wearmin ~ as.factor(dow), data = nhanes)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -261.67 -108.24  -10.55   86.38  621.12
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)      818.882      2.048 399.784  < 2e-16 ***
## as.factor(dow)2   36.599      2.764  13.240  < 2e-16 ***
## as.factor(dow)3   39.281      2.750  14.282  < 2e-16 ***
## as.factor(dow)4   40.428      2.764  14.629  < 2e-16 ***
## as.factor(dow)5   34.328      2.762  12.427  < 2e-16 ***
## as.factor(dow)6   42.792      2.784  15.373  < 2e-16 ***
```

```
## as.factor(dow)7   21.738      2.873   7.566 3.92e-14 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 148.1 on 42433 degrees of freedom
## Multiple R-squared:  0.008106,Adjusted R-squared:  0.007965
## F-statistic: 57.79 on 6 and 42433 DF,  p-value: < 2.2e-16
```

```
summary(lm(wearmin~as.factor(rep),data=nhanes))
```

```
##
## Call:
## lm(formula = wearmin ~ as.factor(rep), data = nhanes)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -258.59 -109.09  -11.53   87.27  615.71
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)      850.727      1.822 466.907  < 2e-16 ***
## as.factor(rep)2    7.868      2.581   3.048  0.00231 **
## as.factor(rep)3    5.366      2.599   2.065  0.03893 *
## as.factor(rep)4    5.782      2.614   2.212  0.02700 *
## as.factor(rep)5    2.224      2.638   0.843  0.39906
## as.factor(rep)6   -2.202      2.684  -0.820  0.41198
## as.factor(rep)7  -26.440      2.807  -9.420  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 148.4 on 42433 degrees of freedom
```

```
## Multiple R-squared:  0.004513,Adjusted R-squared:  0.004372
## F-statistic: 32.06 on 6 and 42433 DF,  p-value: < 2.2e-16
```

```
table(nhanes$rep,nhanes$dow)
```

```
##
##        1    2    3    4    5    6    7
##   1 1507 1482 1180  547  586  543  786
##   2  722 1700 1458 1124  512  567  502
##   3  451  797 1687 1378 1102  480  516
##   4  473  503  789 1638 1368 1062  430
##   5  398  529  486  776 1624 1294  945
##   6  830  472  513  465  764 1545 1080
##   7  847  882  398  445  429  683 1145
```

```
dim(nhanes)
```

```
## [1] 42440    39
```

```
length(unique(nhanes$id))
```

```
## [1] 8244
```

```
table(nrep) #gives distribution of number of replicates
```

```
## nrep
##    1    2    3    4    5    6    7
##  510  555  656  834 1249 1809 2631
```

```
meas7 <- subset(nhanes, id %in% unique(id)[nrep==7]) #individuals with all 7 days
length(unique(meas7$id[complete.cases(meas7[,c("smplwt","sex","age","race","rep","dow","wearmi
```

```
## [1] 1103
```

```r
#no big changes by taking one of the 7 metsynd variables out

id7complete <- unique(meas7$id[complete.cases(meas7[,c("smplwt","sex","age","race","rep","dow",

meas67 <- subset(nhanes, id %in% unique(id)[nrep>=6] & rep <= 6) #individuals with 6 days
length(unique(meas67$id[complete.cases(meas67[,c("smplwt","sex","age","race","rep","dow","wearm

## [1] 1878

meas57 <- subset(nhanes, id %in% unique(id)[nrep>=5] & rep <= 5) #individuals with 6 days
length(unique(meas57$id[complete.cases(meas57[,c("smplwt","sex","age","race","rep","dow","wearm

## [1] 2424

id57complete <- unique(meas57$id[complete.cases(meas57[,c("smplwt","sex","age","race","rep","do

table((meas57 %>% group_by(id) %>% summarise(n=length(id)))$n)

##
##    3    4    5
##  333 1510 3846

table((meas67 %>% group_by(id) %>% summarise(n=length(id)))$n)

##
##    5    6
## 1088 3352
```

```r
q1 <- lm(modvigmin~as.factor(rep),data=nhanes)
nhanes$rep2 <- nhanes$rep
nhanes$rep2[nhanes$rep %in% c(1:5)] <- 1
q2 <- lm(modvigmin~as.factor(rep2),data=nhanes)
```

```r
anova(q1,q2)
```

```
## Analysis of Variance Table
##
## Model 1: modvigmin ~ as.factor(rep)
## Model 2: modvigmin ~ as.factor(rep2)
##   Res.Df      RSS Df Sum of Sq      F Pr(>F)
## 1  42433 35902020
## 2  42437 35904922 -4   -2901.8 0.8574 0.4887
```

```r
q3 <- lm(modvigmin~as.factor(dow),data=nhanes)
q4 <- lm(modvigmin~as.factor(weekend),data=nhanes)
nhanes$dow2 <- nhanes$dow
nhanes$dow2[nhanes$dow %in% c(2:6)] <- 2
q5 <- lm(modvigmin~as.factor(dow2),data=nhanes)

anova(q3,q4)
```

```
## Analysis of Variance Table
##
## Model 1: modvigmin ~ as.factor(dow)
## Model 2: modvigmin ~ as.factor(weekend)
##   Res.Df      RSS Df Sum of Sq      F    Pr(>F)
## 1  42433 35755786
## 2  42438 35773439 -5    -17653 4.1899 0.0008297 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
anova(q3,q5)
```

```
## Analysis of Variance Table
##
```

```
## Model 1: modvigmin ~ as.factor(dow)
## Model 2: modvigmin ~ as.factor(dow2)
##   Res.Df      RSS Df Sum of Sq      F Pr(>F)
## 1  42433 35755786
## 2  42437 35762149 -4     -6363 1.8878 0.1095

q1 <- lm(modvigmin~as.factor(rep),data=meas7)
meas7$rep2 <- meas7$rep
meas7$rep2[meas7$rep %in% c(1:5)] <- 1
q2 <- lm(modvigmin~as.factor(rep2),data=meas7)
anova(q1,q2)

## Analysis of Variance Table
##
## Model 1: modvigmin ~ as.factor(rep)
## Model 2: modvigmin ~ as.factor(rep2)
##   Res.Df      RSS Df Sum of Sq      F Pr(>F)
## 1  18410 14037352
## 2  18414 14038137 -4   -785.07 0.2574 0.9053

q3 <- lm(modvigmin~as.factor(dow),data=meas7)
q4 <- lm(modvigmin~as.factor(weekend),data=meas7)
meas7$dow2 <- meas7$dow
meas7$dow2[meas7$dow %in% c(2:6)] <- 2
q5 <- lm(modvigmin~as.factor(dow2),data=meas7)

anova(q3,q4)

## Analysis of Variance Table
##
## Model 1: modvigmin ~ as.factor(dow)
## Model 2: modvigmin ~ as.factor(weekend)
```

```
##   Res.Df      RSS Df Sum of Sq     F Pr(>F)
## 1  18410 13976558
## 2  18415 13983155 -5   -6597.3 1.738 0.1221
```

```
anova(q3,q5)
```

```
## Analysis of Variance Table
##
## Model 1: modvigmin ~ as.factor(dow)
## Model 2: modvigmin ~ as.factor(dow2)
##   Res.Df      RSS Df Sum of Sq      F Pr(>F)
## 1  18410 13976558
## 2  18414 13977073 -4   -515.62 0.1698 0.9539
```

```
m1a <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas7,correlation=corCompSymm(form=~1|i
m2a <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas7,correlation=corAR1(form=~1|id),me
m3a <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas7,correlation=corARMA(form=~1|id,p=
m4a <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas7,correlation=corARMA(form=~1|id,p=
m6a <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas7,correlation=corARMA(form=~1|id,p=
m7a <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas7,correlation=corSymm(form=~1|id),m
m8a <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas7,correlation=corSymm(form=~1|id),w
```

```
extractAIC(m1a)
```

```
## [1]     15.0 164398.1
```

```
extractAIC(m2a)
```

```
## [1]     15.0 166262.7
```

```
extractAIC(m3a)
```

```
## [1]     16.0 164252.2
```

```
extractAIC(m4a)
```

```
## [1]     16.0 164938.2
```

```
extractAIC(m6a)
```

```
## [1]     17.0 164181.5
```

```
extractAIC(m7a)
```

```
## [1]     35.0 164043.4
```

```
extractAIC(m8a)
```

```
## [1]     41.0 164029.9
```

```
anova(m3a,m2a)
```

```
##     Model df      AIC      BIC    logLik   Test  L.Ratio p-value
## m3a     1 16 164252.2 164377.3 -82110.08
## m2a     2 15 166262.8 166380.1 -83116.37 1 vs 2 2012.582  <.0001
```

```
anova(m6a,m3a)
```

```
##     Model df      AIC      BIC    logLik   Test  L.Ratio p-value
## m6a     1 17 164181.5 164314.4 -82073.73
## m3a     2 16 164252.2 164377.3 -82110.08 1 vs 2 72.71033  <.0001
```

```
anova(m7a,m6a)
```

```
##     Model df      AIC      BIC    logLik   Test  L.Ratio p-value
## m7a     1 35 164043.4 164317.1 -81986.68
## m6a     2 17 164181.5 164314.4 -82073.73 1 vs 2 174.0954  <.0001
```

```
anova(m8a,m7a)
```

```
##     Model df      AIC      BIC    logLik   Test  L.Ratio p-value
## m8a     1 41 164029.9 164350.5 -81973.94
## m7a     2 35 164043.4 164317.1 -81986.68 1 vs 2 25.47542   3e-04
```

```
meas57sub <- subset(meas57,rep <=5)

m1b <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas57sub,correlation=corCompSymm(form=
m2b <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas57sub,correlation=corAR1(form=~1|id
m3b <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas57sub,correlation=corARMA(form=~1|i
m4b <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas57sub,correlation=corARMA(form=~1|i
m6b <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas57sub,correlation=corARMA(form=~1|i
m7b <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas57sub,correlation=corSymm(form=~1|i
m8b <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas57,correlation=corSymm(form=~1|id),

extractAIC(m1b)
```

```
## [1]     13 238400
```

```
extractAIC(m2b)
```

```
## [1]     13.0 240187.2
```

```
extractAIC(m3b)
```

```
## [1]     14.0 238171.1
```

```
extractAIC(m4b)
```

```
## [1]     14.0 238567.7
```

```
extractAIC(m6b)
```

```
## [1]     15 238171
```

```
extractAIC(m7b)
```

```
## [1]     22.0 238067.3
```

```
extractAIC(m8b)
```

```
## [1]     26.0 238041.9
```

```
anova(m3b,m2b)
```

```
##     Model df      AIC      BIC    logLik   Test  L.Ratio p-value
## m3b     1 14 238171.1 238285.6 -119071.6
## m2b     2 13 240187.2 240293.5 -120080.6 1 vs 2 2018.088  <.0001
```

```
anova(m6b,m3b)
```

```
##     Model df      AIC      BIC    logLik   Test  L.Ratio p-value
## m6b     1 15 238171.0 238293.7 -119070.5
## m3b     2 14 238171.1 238285.6 -119071.6 1 vs 2 2.070635  0.1502
```

```
anova(m7b,m3b)
```

```
##     Model df      AIC      BIC    logLik   Test  L.Ratio p-value
## m7b     1 22 238067.3 238247.2 -119011.6
## m3b     2 14 238171.1 238285.6 -119071.6 1 vs 2 119.8111  <.0001
```

```
anova(m8b,m7b)
```

```
##     Model df      AIC      BIC    logLik   Test  L.Ratio p-value
## m8b     1 26 238041.9 238254.4 -118994.9
## m7b     2 22 238067.3 238247.2 -119011.6 1 vs 2 33.45403  <.0001
```

```r
meas67sub <- subset(meas67,rep <=6)

m1c <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas67sub,correlation=corCompSymm(form=
m2c <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas67sub,correlation=corAR1(form=~1|id
m3c <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas67sub,correlation=corARMA(form=~1|i
m4c <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas67sub,correlation=corARMA(form=~1|i
m6c <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas67sub,correlation=corARMA(form=~1|i
m7c <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas67sub,correlation=corSymm(form=~1|i
m8c <- gls(modvigmin~as.factor(dow)+as.factor(rep),data=meas67sub,correlation=corSymm(form=~1|i

extractAIC(m1c)

## [1]     14.0 230404.8

extractAIC(m2c)

## [1]     14.0 232528.5

extractAIC(m3c)

## [1]     15 230100

extractAIC(m4c)

## [1]     15.0 230692.3

extractAIC(m6c)

## [1]     16.0 230093.7

extractAIC(m7c)

## [1]     28.0 229972.9
```

```
extractAIC(m8c)
```

```
## [1]     33.0 229956.5
```

```
anova(m3c,m2c)
```

```
##     Model df      AIC      BIC    logLik   Test  L.Ratio p-value
## m3c     1 15 230100.0 230222.2 -115035.0
## m2c     2 14 232528.5 232642.6 -116250.2 1 vs 2 2430.536  <.0001
```

```
anova(m6c,m3c)
```

```
##     Model df      AIC      BIC    logLik   Test  L.Ratio p-value
## m6c     1 16 230093.7 230224.0 -115030.8
## m3c     2 15 230100.0 230222.2 -115035.0 1 vs 2 8.293493   0.004
```

```
anova(m7c,m6c)
```

```
##     Model df      AIC    BIC    logLik   Test  L.Ratio p-value
## m7c     1 28 229972.9 230201 -114958.4
## m6c     2 16 230093.7 230224 -115030.8 1 vs 2 144.7848  <.0001
```

```
anova(m7c,m8c)
```

```
##     Model df      AIC      BIC    logLik   Test  L.Ratio p-value
## m7c     1 28 229972.9 230201.0 -114958.4
## m8c     2 33 229956.5 230225.4 -114945.3 1 vs 2 26.35735   1e-04
```

```
lme1 <- lme(modvigmin~as.factor(dow)+as.factor(rep),random=~1|id,data=meas7,correlation=corSymm
```

```
summary(m8a) #gls without random effects
```

```
## Generalized least squares fit by maximum likelihood
##   Model: modvigmin ~ as.factor(dow) + as.factor(rep)
##   Data: meas7
##        AIC      BIC    logLik
##   164029.9 164350.5 -81973.94
##
## Correlation Structure: General
##  Formula: ~1 | id
##  Parameter estimate(s):
##  Correlation:
##   1     2     3     4     5     6
## 2 0.600
## 3 0.583 0.651
## 4 0.523 0.578 0.658
## 5 0.550 0.608 0.661 0.682
## 6 0.561 0.536 0.603 0.600 0.634
## 7 0.558 0.539 0.557 0.517 0.554 0.586
## Variance function:
##  Structure: Different standard deviations per stratum
##  Formula: ~1 | rep
##  Parameter estimates:
##         1         2         3         4         5         6         7
## 1.0000000 0.9823352 1.0260409 1.0028533 1.0260458 0.9976716 0.9599137
##
## Coefficients:
##                     Value Std.Error   t-value p-value
## (Intercept)     17.195103 0.6072096 28.318233  0.0000
## as.factor(dow)2  5.415249 0.4702770 11.515019  0.0000
## as.factor(dow)3  5.052452 0.4976650 10.152314  0.0000
```

```
## as.factor(dow)4  4.876995 0.5138790  9.490551  0.0000
## as.factor(dow)5  4.907845 0.5136416  9.554999  0.0000
## as.factor(dow)6  4.647601 0.4972114  9.347334  0.0000
## as.factor(dow)7  2.268762 0.4728772  4.797782  0.0000
## as.factor(rep)2 -0.539641 0.4805194 -1.123037  0.2614
## as.factor(rep)3 -0.308111 0.5049796 -0.610145  0.5418
## as.factor(rep)4 -0.384855 0.5367814 -0.716967  0.4734
## as.factor(rep)5 -0.081066 0.5277860 -0.153596  0.8779
## as.factor(rep)6 -0.831819 0.5105435 -1.629282  0.1033
## as.factor(rep)7 -1.590955 0.4992559 -3.186652  0.0014
##
##  Correlation:
##                 (Intr) as.fctr(d)2 as.fctr(d)3 as.fctr(d)4 as.fctr(d)5
## as.factor(dow)2 -0.363
## as.factor(dow)3 -0.376  0.537
## as.factor(dow)4 -0.355  0.500       0.585
## as.factor(dow)5 -0.358  0.471       0.533       0.601
## as.factor(dow)6 -0.337  0.435       0.475       0.529       0.581
## as.factor(dow)7 -0.342  0.442       0.439       0.467       0.505
## as.factor(rep)2 -0.365 -0.095      -0.075      -0.105      -0.054
## as.factor(rep)3 -0.314 -0.074      -0.141      -0.153      -0.135
## as.factor(rep)4 -0.368 -0.030      -0.080      -0.168      -0.138
## as.factor(rep)5 -0.336 -0.036      -0.049      -0.126      -0.171
## as.factor(rep)6 -0.385  0.019      -0.003      -0.047      -0.078
## as.factor(rep)7 -0.423 -0.016       0.017      -0.034      -0.029
##                 as.fctr(d)6 as.fctr(d)7 as.fctr(r)2 as.fctr(r)3
## as.factor(dow)2
## as.factor(dow)3
## as.factor(dow)4
## as.factor(dow)5
## as.factor(dow)6
```

```
## as.factor(dow)7  0.538
## as.factor(rep)2 -0.060      -0.020
## as.factor(rep)3 -0.093      -0.062       0.574
## as.factor(rep)4 -0.131      -0.054       0.525       0.619
## as.factor(rep)5 -0.151      -0.108       0.531       0.599
## as.factor(rep)6 -0.137      -0.075       0.443       0.522
## as.factor(rep)7 -0.070      -0.093       0.461       0.474
##                 as.fctr(r)4 as.fctr(r)5 as.fctr(r)6
## as.factor(dow)2
## as.factor(dow)3
## as.factor(dow)4
## as.factor(dow)5
## as.factor(dow)6
## as.factor(dow)7
## as.factor(rep)2
## as.factor(rep)3
## as.factor(rep)4
## as.factor(rep)5  0.660
## as.factor(rep)6  0.565       0.591
## as.factor(rep)7  0.479       0.503       0.542
##
## Standardized residuals:
##        Min         Q1        Med         Q3        Max
## -0.8204756 -0.6334503 -0.3732255  0.2776025 11.0484393
##
## Residual standard error: 27.55761
## Degrees of freedom: 18417 total; 18404 residual

summary(lme1) #lme with person random effects

## Linear mixed-effects model fit by maximum likelihood
```

```
##  Data: meas7
##        AIC      BIC    logLik
##   164031.9 164360.4 -81973.94
##
## Random effects:
##  Formula: ~1 | id
##         (Intercept) Residual
## StdDev:    20.94626  17.9077
##
## Correlation Structure: General
##  Formula: ~1 | id
##  Parameter estimate(s):
##  Correlation:
##   1      2      3      4      5      6
## 2  0.029
## 3  0.047  0.183
## 4 -0.125 -0.022  0.220
## 5 -0.029  0.083  0.248  0.275
## 6 -0.042 -0.130  0.090  0.053  0.159
## 7 -0.110 -0.189 -0.072 -0.208 -0.079 -0.045
## Variance function:
##  Structure: Different standard deviations per stratum
##  Formula: ~1 | rep
##  Parameter estimates:
##         1         2         3         4         5         6         7
## 1.0000000 0.9576252 1.0606082 1.0067280 1.0606237 0.9944680 0.9021843
## Fixed effects: modvigmin ~ as.factor(dow) + as.factor(rep)
##                     Value Std.Error    DF   t-value p-value
## (Intercept)     17.195092 0.6072126 15774 28.318077  0.0000
## as.factor(dow)2  5.415249 0.4702767 15774 11.515027  0.0000
## as.factor(dow)3  5.052471 0.4976649 15774 10.152357  0.0000
```

```
## as.factor(dow)4  4.877019 0.5138789 15774  9.490600  0.0000
## as.factor(dow)5  4.907868 0.5136415 15774  9.555045  0.0000
## as.factor(dow)6  4.647623 0.4972113 15774  9.347380  0.0000
## as.factor(dow)7  2.268769 0.4728769 15774  4.797801  0.0000
## as.factor(rep)2 -0.539643 0.4805191 15774 -1.123041  0.2614
## as.factor(rep)3 -0.308116 0.5049787 15774 -0.610157  0.5418
## as.factor(rep)4 -0.384862 0.5367819 15774 -0.716979  0.4734
## as.factor(rep)5 -0.081071 0.5277859 15774 -0.153607  0.8779
## as.factor(rep)6 -0.831823 0.5105435 15774 -1.629289  0.1033
## as.factor(rep)7 -1.590955 0.4992550 15774 -3.186659  0.0014
##  Correlation:
##                 (Intr) as.fctr(d)2 as.fctr(d)3 as.fctr(d)4 as.fctr(d)5
## as.factor(dow)2 -0.363
## as.factor(dow)3 -0.376  0.537
## as.factor(dow)4 -0.355  0.500       0.585
## as.factor(dow)5 -0.358  0.471       0.533       0.601
## as.factor(dow)6 -0.337  0.435       0.475       0.529       0.581
## as.factor(dow)7 -0.342  0.442       0.439       0.467       0.505
## as.factor(rep)2 -0.365 -0.095      -0.075      -0.105      -0.054
## as.factor(rep)3 -0.314 -0.074      -0.141      -0.153      -0.135
## as.factor(rep)4 -0.368 -0.030      -0.080      -0.168      -0.138
## as.factor(rep)5 -0.336 -0.036      -0.049      -0.126      -0.171
## as.factor(rep)6 -0.385  0.019      -0.003      -0.047      -0.078
## as.factor(rep)7 -0.423 -0.016       0.017      -0.034      -0.029
##                 as.fctr(d)6 as.fctr(d)7 as.fctr(r)2 as.fctr(r)3
## as.factor(dow)2
## as.factor(dow)3
## as.factor(dow)4
## as.factor(dow)5
## as.factor(dow)6
## as.factor(dow)7  0.538
```

```
## as.factor(rep)2 -0.060      -0.020
## as.factor(rep)3 -0.093      -0.062       0.574
## as.factor(rep)4 -0.131      -0.054       0.525       0.619
## as.factor(rep)5 -0.151      -0.108       0.531       0.599
## as.factor(rep)6 -0.137      -0.075       0.443       0.522
## as.factor(rep)7 -0.070      -0.093       0.461       0.474
##                 as.fctr(r)4 as.fctr(r)5 as.fctr(r)6
## as.factor(dow)2
## as.factor(dow)3
## as.factor(dow)4
## as.factor(dow)5
## as.factor(dow)6
## as.factor(dow)7
## as.factor(rep)2
## as.factor(rep)3
## as.factor(rep)4
## as.factor(rep)5  0.660
## as.factor(rep)6  0.565       0.591
## as.factor(rep)7  0.479       0.503       0.542
##
## Standardized Within-Group Residuals:
##        Min         Q1        Med         Q3        Max
## -8.4620780 -0.3520519 -0.1234935  0.2129186  9.6612390
##
## Number of Observations: 18417
## Number of Groups: 2631
```

```
meas7$error <- meas7$modvigmin  - predict(lme1)
eht <- meas7 %>% group_by(id) %>% summarise(e1=error[1],e2=error[2],e3=error[3],e4=error[4],e5=


# ind <- which(!is.na(eht£e7))
```

```r
# boxtest <- rep(0,length(ind))
# for(i in 1:length(ind)){
#   boxtest[i] <- Box.test(unlist(eht[ind[i],-1]),lag=2,type="Ljung-Box")$p.value
# }
# summary(boxtest)

#lag 1 difference
o1a = c(eht$e1,eht$e2,eht$e3,eht$e4,eht$e5,eht$e6)
o1b = c(eht$e2,eht$e3,eht$e4,eht$e5,eht$e6,eht$e7)
cor(o1a,o1b)
```

```
## [1] 0.03687864
```

```r
#lag 2 diff
o2a = c(eht$e1,eht$e2,eht$e3,eht$e4,eht$e5)
o2b = c(eht$e3,eht$e4,eht$e5,eht$e6,eht$e7)
cor(o2a,o2b)
```

```
## [1] -0.05977463
```

```r
#lag 3 diff
o3a = c(eht$e1,eht$e2,eht$e3,eht$e4)
o3b = c(eht$e4,eht$e5,eht$e6,eht$e7)
cor(o3a,o3b)
```

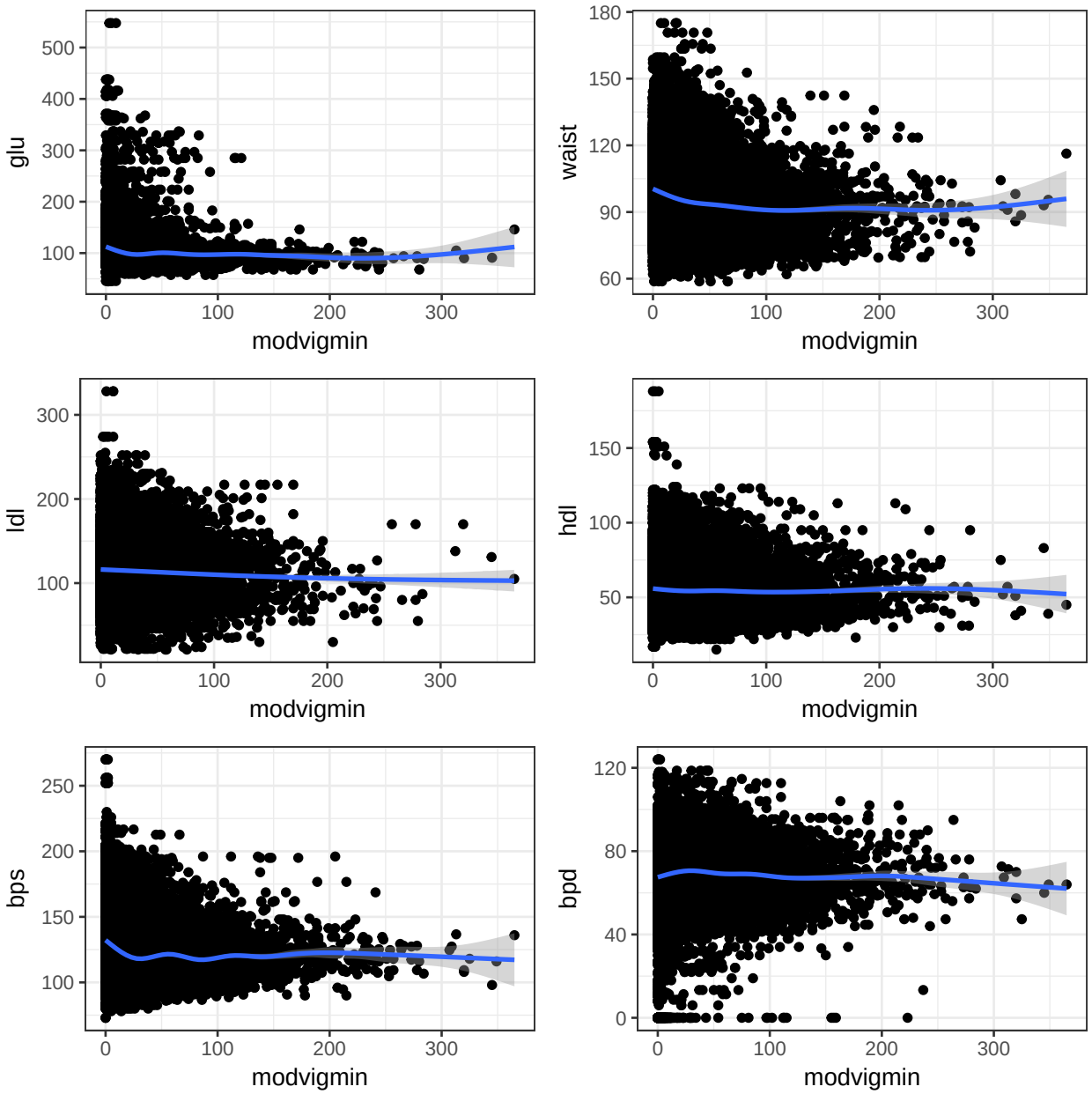
```
## [1] -0.1641883
```

```r
#lag 4 diff
o4a = c(eht$e1,eht$e2,eht$e3)
o4b = c(eht$e5,eht$e6,eht$e7)
cor(o4a,o4b)
```

```
## [1] -0.2107862
```

```r
#lag 5 diff
o5a = c(eht$e1,eht$e2)
o5b = c(eht$e6,eht$e7)
cor(o5a,o5b)

## [1] -0.2622573
```

```
## `geom_smooth()` using method = 'gam'
## Warning: Removed 22850 rows containing non-finite values (stat_smooth).
## Warning: Removed 22850 rows containing missing values (geom_point).
## `geom_smooth()` using method = 'gam'
## Warning: Removed 986 rows containing non-finite values (stat_smooth).
## Warning: Removed 986 rows containing missing values (geom_point).
## `geom_smooth()` using method = 'gam'
## Warning: Removed 23477 rows containing non-finite values (stat_smooth).
## Warning: Removed 23477 rows containing missing values (geom_point).
## `geom_smooth()` using method = 'gam'
## Warning: Removed 1531 rows containing non-finite values (stat_smooth).
## Warning: Removed 1531 rows containing missing values (geom_point).
## `geom_smooth()` using method = 'gam'
## Warning: Removed 1781 rows containing non-finite values (stat_smooth).
## Warning: Removed 1781 rows containing missing values (geom_point).
## `geom_smooth()` using method = 'gam'
## Warning: Removed 1781 rows containing non-finite values (stat_smooth).
## Warning: Removed 1781 rows containing missing values (geom_point).
```




```
summary(nhanes$wearmin)
```

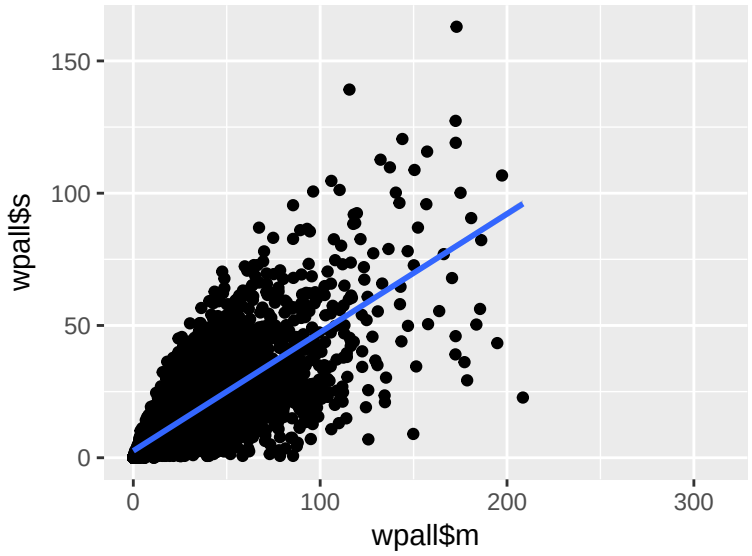
```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   600.0   741.0   839.0   850.6   938.0  1440.0
```

```
summary(meas7$wearmin)
```

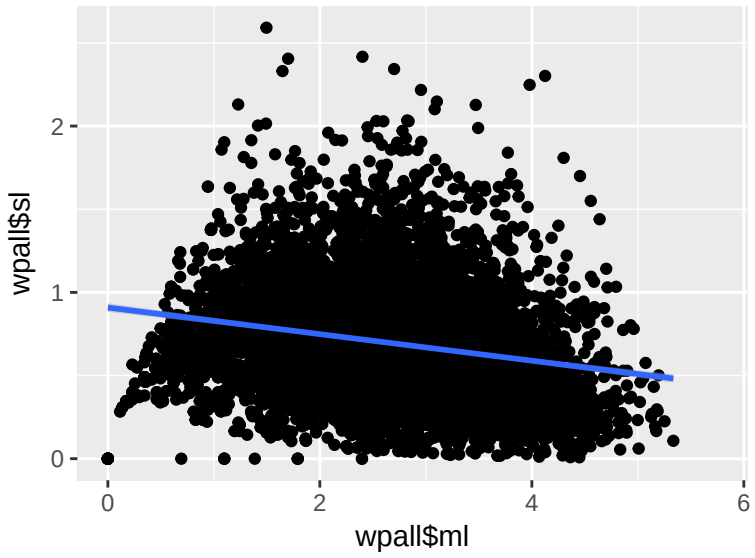
```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   600.0   787.0   876.0   885.8   965.0  1440.0
```

```r
minweartime <- (meas7 %>% group_by(id) %>% summarise(minimum=min(wearmin),avg=mean(wearmin)))

sum(minweartime$minimum[minweartime$id %in% id7complete] > 1000)

## [1] 21

sum(minweartime$minimum[minweartime$id %in% id7complete] > 800)

## [1] 254

sum(minweartime$minimum[minweartime$id %in% id7complete] > 700)

## [1] 663

summary(minweartime$avg[minweartime$id %in% id7complete])

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   654.6   821.9   873.6   885.6   928.8  1385.0

minweartime5 <- (meas57 %>% group_by(id) %>% summarise(minimum=min(wearmin),avg=mean(wearmin)))

sum(minweartime5$minimum[minweartime5$id %in% id57complete] > 1000)

## [1] 66

sum(minweartime5$minimum[minweartime5$id %in% id57complete] > 800)

## [1] 691

sum(minweartime5$minimum[minweartime5$id %in% id57complete] > 700)

## [1] 1528

summary(minweartime5$avg[minweartime5$id %in% id57complete])

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   624.0   790.3   854.0   865.0   920.6  1398.0
```

```
wpall <- nhanes %>% group_by(id)  %>% summarise(m=mean(modvigmin),s=sd(modvigmin),ml=mean(log(m
qplot(x=wpall$m,y=wpall$s) + geom_smooth(method="lm")

## Warning:  Removed 510 rows containing non-finite values (stat_smooth).

## Warning:  Removed 510 rows containing missing values (geom_point).
```




```
qplot(x=wpall$ml,y=wpall$sl)+ geom_smooth(method="lm")

## Warning:  Removed 2135 rows containing non-finite values (stat_smooth).

## Warning:  Removed 2135 rows containing missing values (geom_point).
```



```r
nhanes$bmigroup <- 1
nhanes$bmigroup[nhanes$bmi >= 18] <- 2
nhanes$bmigroup[nhanes$bmi >= 25] <- 3
nhanes$bmigroup[nhanes$bmi >= 30] <- 4
nhanes$bmigroup[nhanes$bmi >= 35] <- 5

nhanes$agegroup <- 1
nhanes$agegroup[nhanes$age >= 25] <- 2
nhanes$agegroup[nhanes$age >= 35] <- 3
nhanes$agegroup[nhanes$age >= 45] <- 4
nhanes$agegroup[nhanes$age >= 55] <- 5
nhanes$agegroup[nhanes$age >= 65] <- 6

nhanes %>% group_by(sex) %>% summarise(mean(wearmin),sd(wearmin)/sqrt(length(wearmin)))
```

```
## # A tibble: 2  3
##     sex `mean(wearmin)` `sd(wearmin)/sqrt(length(wearmin))`
##   <int>           <dbl>                               <dbl>
## 1     1        862.4040                           1.0745519
## 2     2        839.2255                           0.9610608
```

```r
nhanes %>% group_by(race) %>% summarise(mean(wearmin),sd(wearmin)/sqrt(length(wearmin)))
```

```
## # A tibble: 5  3
##    race `mean(wearmin)` `sd(wearmin)/sqrt(length(wearmin))`
##   <int>           <dbl>                               <dbl>
## 1     1        838.3973                            1.504752
## 2     2        837.8630                            4.226087
## 3     3        848.6774                            0.944356
## 4     4        868.9508                            1.864345
## 5     5        855.5710                            3.544238
```

```
nhanes %>% group_by(bmigroup) %>% summarise(mean(wearmin),sd(wearmin)/sqrt(length(wearmin)))
```

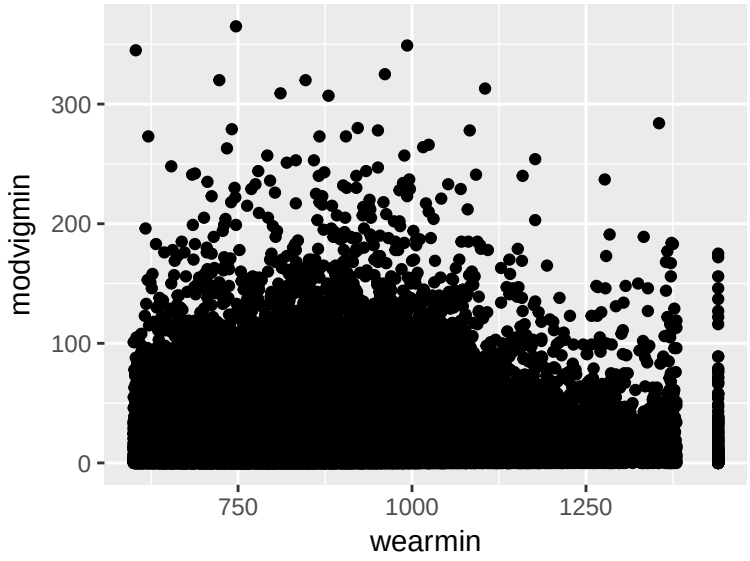
```
## # A tibble: 5  3
##   bmigroup `mean(wearmin)` `sd(wearmin)/sqrt(length(wearmin))`
##      <dbl>           <dbl>                               <dbl>
## 1        1        853.8333                            7.185609
## 2        2        851.4379                            1.257627
## 3        3        855.4751                            1.212399
## 4        4        847.2281                            1.658649
## 5        5        839.8965                            2.096613
```

```
nhanes %>% group_by(agegroup) %>% summarise(mean(wearmin),sd(wearmin)/sqrt(length(wearmin)))
```

```
## # A tibble: 6  3
##   agegroup `mean(wearmin)` `sd(wearmin)/sqrt(length(wearmin))`
##      <dbl>           <dbl>                               <dbl>
## 1        1        841.3575                            2.053093
## 2        2        845.0387                            1.823399
## 3        3        856.7826                            1.809899
## 4        4        876.1550                            1.893967
## 5        5        853.2721                            1.875862
## 6        6        839.1086                            1.365020
```

```
#nhanes %>% group_by(sex,race,bmigroup) %>% summarise(mean(wearmin),sd(wearmin)/sqrt(length(wea
```

```
qplot(x=wearmin,y=modvigmin,data=nhanes)
```




```
qplot(x=wearmin,y=lightmin,data=nhanes)
```