The Relationship Between Exercise Time and Weight Loss

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```
## Warning: package 'tidyr' was built under R version 3.6.2

##
## 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

##
## Attaching package: 'reshape2'

## The following object is masked from 'package:tidyr':
##
##     smiths
```


Abstract

The purpose of this data analysis is to apply statistical models to health data for a call center. While there were many data points missing for weight gain and the total metabolic minutes, many of these could be found using the other metrics available. The health data was processed to provide as many viable data points as possible without compromising the integrity of the analysis. Two models were constructed: a linear model to examine the relationship between total metabolic minutes and weight gain and a logistic regression model to examine the relationship between shift time and weight gain.

Introduction

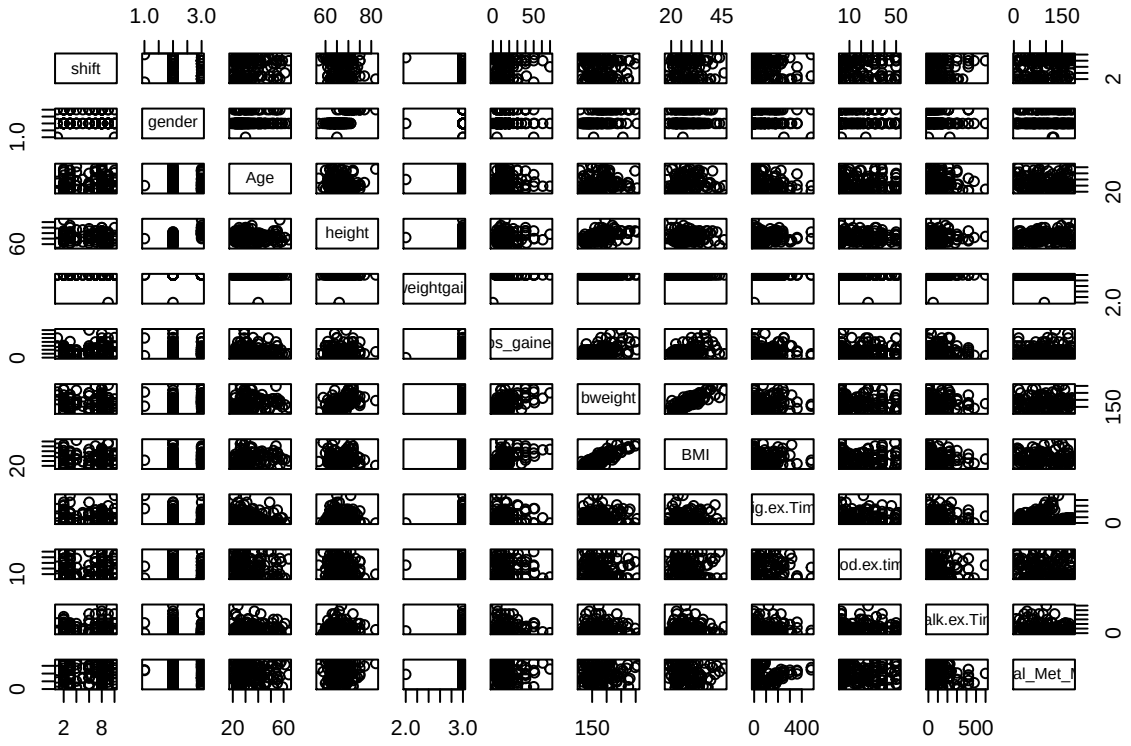
We have been given several health measurements of employees working at a call center. Over eight months, the metrics have tracked information including work shift time, exercise time, weight gained (binary yes/no measurement), amount of weight gained, total metabolic minutes, and more. We hope to figure out whether certain factors, specifically total metabolic minutes and shift time, play a role in employees' weight gain.

The Data

The data used in this analysis was provided by the call center. The data consists of 392 observations and 83 features, with variables such as member information, body measurements, exercise time, and weight situation. There are thirteen variables that we will use for this analysis, including shift time, gender, age, height, weight gain, pounds gained, body weight, body mass index, vigorous exercise time, moderate exercise time, walking

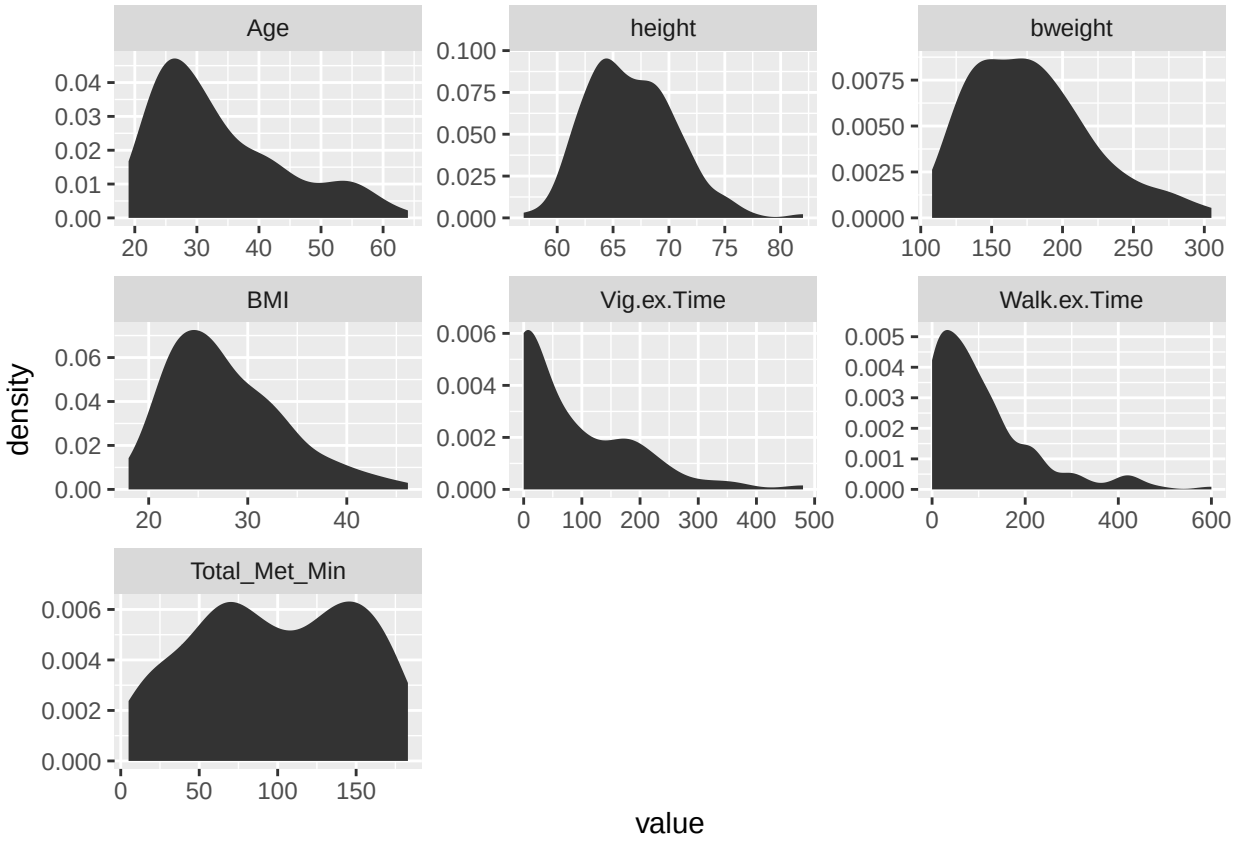
exercise time, and total metabolic minutes. It is important to note that there were many missing values for total metabolic minutes, but these could be filled in using the other variables available. There were also missing values for pounds gained, but no features were available to account for this so these observations were removed.

We load and subset the raw data into a new dataset that contains the columns that we will use for our analysis. After the initial examination of the data, we renamed several variables by eliminating white spaces in order to improve the easiness of analysis. Using the formula provided, Total_met_min = 8 * Vig_ex_time + 4 * Mod_ex_time + 3.3 * Walk_ex_time, we filled in the missing values of variable Total_Met_Min.



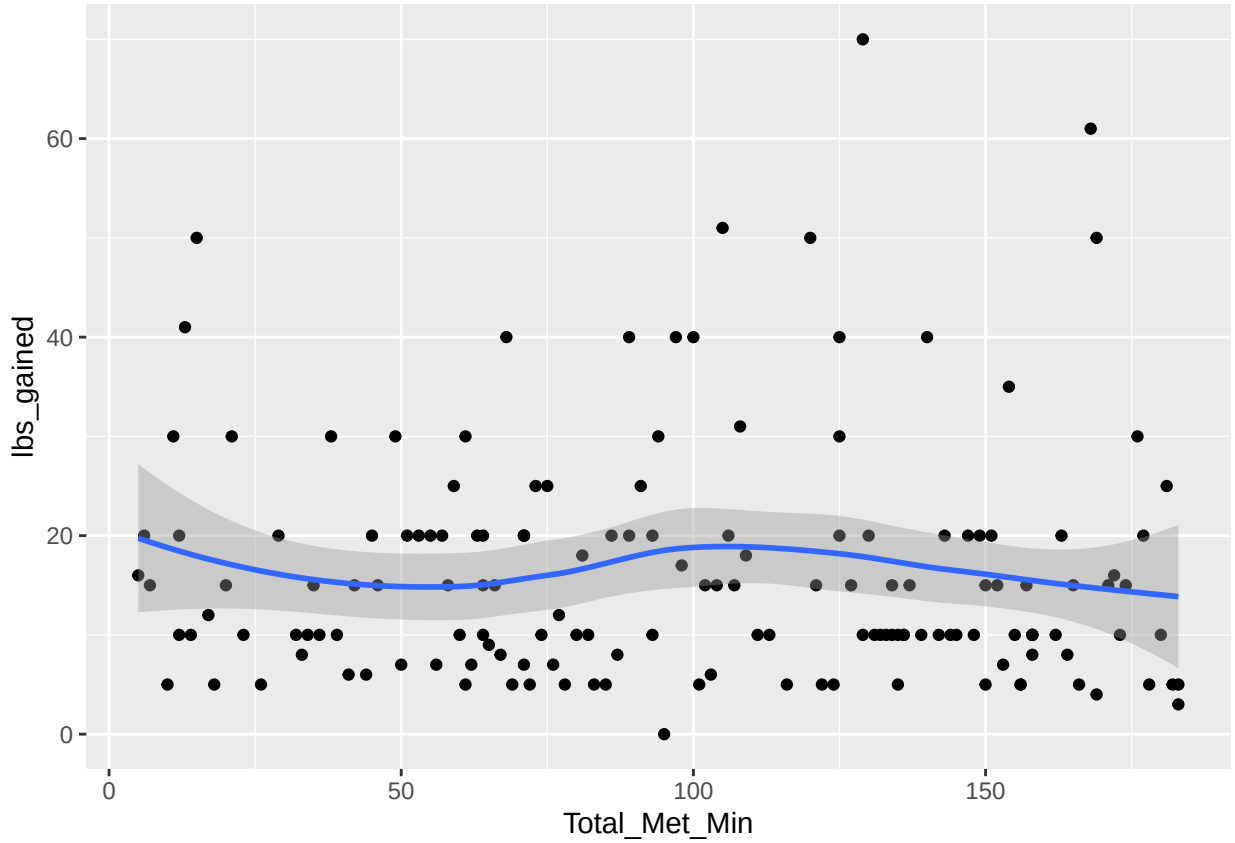

```
## Using Mod.ex.time as id variables
```

```
## Warning: Removed 82 rows containing non-finite values (stat_density).
```



We see that Age and BMI are right-skewed with nonzero values, so we will do a log transformation on these variables.

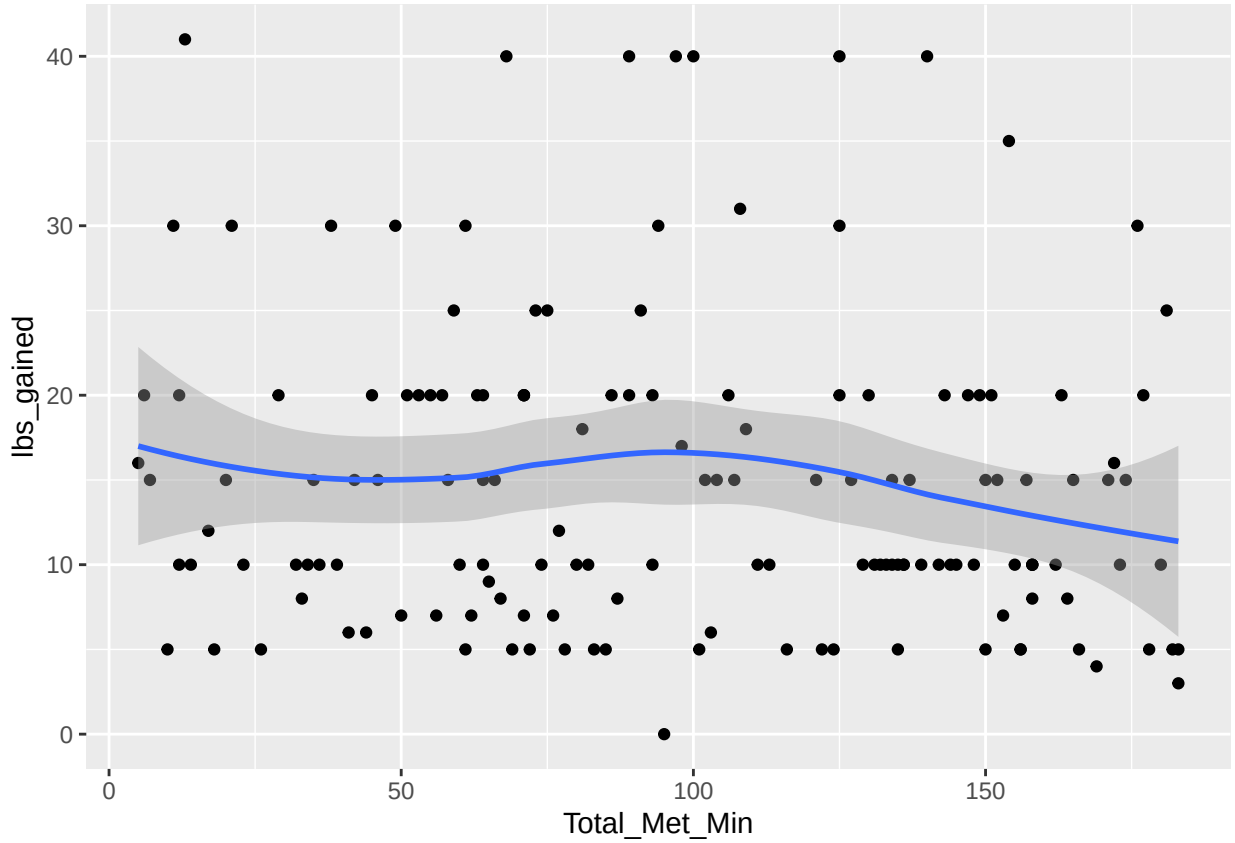
```
##
## Call:
## lm(formula = lbs_gained ~ Total_Met_Min, data = dat1)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -16.406  -7.288  -1.913   3.543  53.824
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)   17.048084   2.115141   8.060 2.03e-13 ***
## Total_Met_Min -0.006761   0.019050  -0.355    0.723
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 12.05 on 153 degrees of freedom
## Multiple R-squared:  0.0008225,  Adjusted R-squared:  -0.005708
## F-statistic: 0.126 on 1 and 153 DF,  p-value: 0.7232

## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```




```
##
## Call:
## lm(formula = lbs_gained ~ Total_Met_Min, data = dat1)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -14.875  -6.588  -3.225   4.470  26.077
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)   16.88414    1.62851  10.368   <2e-16 ***
## Total_Met_Min -0.02115    0.01477  -1.432    0.154
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.127 on 147 degrees of freedom
## Multiple R-squared:  0.01376,    Adjusted R-squared:  0.007054
## F-statistic: 2.051 on 1 and 147 DF,  p-value: 0.1542
```

P-value got bigger

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```



Risheng: replace lbs_gained value with 0 if weightgain = 0 and drop the rows that both weightgain and lbs_gained are missing. Also calculate the beginning weight by subtracting lbs_gain from body weight. Calculate the change in BMI using begeinning weight and height.

By turning weightgain into a dummy variable and running a logistic regression, we can measure if other variables have influence on weightgain. First, we factored the two categorical variables and built a model with variables include shift, gender, Age, height and Beg_BMI and Total_Met_Min. Because the change in BMI is very minimal, we decided to use the beginning BMI as one of the regressors. The half normal plot shows that there is no obvious outliers in the model:

```
##     shift gender      Age height weightgain lbs_gained bweight      BMI
## 1     8am Female 3.258097     62        Yes         18     124 3.121483
## 2     9am Female 3.295837     65        Yes          6     151 3.223664
## 3     9am   Male 3.688879     69        Yes         10     180 3.280159
## 4     7am   Male 3.951244     72        Yes         20     190 3.249211
## 5     7am Female 4.060443     62        Yes         20      NA       NA
## 6   other Female 3.135494     NA        Yes          5      NA       NA
## 7     8am Female 3.496508     62        Yes         15     155 3.344627
## 8     8am   Male 3.401197     75        Yes          8     160 2.995732
## 9     8am Female 4.077537     63        Yes         10     150 3.279783
## 10    8am Female 3.713572     68        Yes         10     205 3.439456
## 11    8am Female 3.135494     64        Yes         10      NA       NA
## 12    8am   Male 3.091042     72        Yes         20     235 3.461665
## 13    7am   Male 3.988984     72        Yes         40     298 3.699077
## 14    8am   Male 3.988984     69        Yes         20     185 3.307619
```

```
## 15   11am Female 3.737670     66        Yes         20     209 3.518388
## 16    7am   Male 3.713572     70        Yes         10     204 3.376563
## 17  other Female 3.737670     63        Yes          5     129 3.128951
## 18    8am Female 3.737670     57        Yes         10     113 3.196630
## 19    8am Female       NA     NA        Yes          3      NA       NA
## 20    8am Female 3.828641     64        Yes         15     140 3.179303
## 21    9am Female 3.688879     66         No          0      NA       NA
## 22    8am   Male 3.401197     75        Yes         40     225 3.336481
## 23    9am Female 3.218876     60        Yes         30      NA       NA
## 24    9am Female 3.401197     61        Yes         15     135 3.239071
## 25    9am Female 3.828641     62        Yes         20     120 3.088767
## 26    8am Female 3.295837     64        Yes          7      NA       NA
## 27   10am Female 3.258097     62        Yes         31     170 3.436886
## 28   10am   Male 3.135494     69        Yes          5     170 3.222868
## 29   11am   Male 4.007333     65        Yes          5     108 2.888704
## 30    9am Female 3.091042     64        Yes          5     120 3.025291
## 31    8am   Male 3.218876     71        Yes         20      NA       NA
## 32    8am Female 3.091042     64        Yes          7     132 3.120601
## 33   10am   Male 3.850148     68        Yes         25     200 3.414772
## 34   10am Female 3.044522     64        Yes          5     130 3.105035
## 35    8am Female 3.178054     67        Yes          5     173 3.299165
## 36        Female 3.526361     61        Yes         30     202 3.641788
## 37  other Female 3.332205     65        Yes          5     135 3.111736
## 38    9am Female 3.178054     63        Yes         10      NA       NA
## 39   12pm Female 3.401197     64        Yes         10     269 3.832330
## 40   11am Female 3.258097     63        Yes          8     132 3.151881
## 41   11am   Male 3.178054     69        Yes          8     150 3.097837
## 42    2pm Female 3.044522     63        Yes         15     118 3.039749
## 43    1pm Female 3.135494     67        Yes          5     155 3.189241
## 44   11am Female 3.688879     61        Yes         41      NA       NA
## 45    2pm Female 3.401197     66        Yes         10     140 3.117507
## 46    2pm Female 3.465736     66        Yes         10      NA       NA
## 47  other Female 3.332205     66        Yes         10      NA       NA
## 48    2pm   Male       NA     NA        Yes         10     173       NA
## 49    9am   Male       NA     NA        Yes         25     180       NA
## 50    8am Female 3.332205     69        Yes         15     180 3.280159
## 51    2pm   Male       NA     72        Yes         30     250 3.523415
## 52    8am Female 3.806662     62        Yes         18     167 3.419037
## 53   11am Female 3.218876     67        Yes         20     155 3.189241
## 54    9am Female 3.295837     59        Yes         10     217 3.780090
## 55  other Female 4.007333     60        Yes         30     170 3.502550
## 56    8am Female 3.433987     63        Yes          7      NA       NA
## 57    8am Female 3.496508     64        Yes         10      NA       NA
## 58    8am Female 3.295837     67        Yes         20     145 3.122805
## 59    2pm Female 3.178054     65        Yes         17      NA       NA
## 60    8am Female 3.295837     69        Yes         15      NA       NA
## 61    1pm Female 3.688879     62        Yes          5      NA       NA
## 62   11am Female 3.583519     61        Yes         10      NA       NA
## 63    9am Female 3.401197     61        Yes          5     139 3.268047
## 64   10am Female 3.367296     63        Yes         30     235 3.728581
## 65    7am Female 3.218876     66        Yes         10     128 3.028199
## 66    8am   Male 3.258097     69        Yes         20     220 3.480625
## 67    8am   Male 3.433987     72        Yes         40     250 3.523415
## 68   12pm   Male 3.401197     73        Yes          5     200 3.272606
```

```
## 69    8am   Male       NA     NA        Yes          8     194       NA
## 70    8am Female 3.806662     68        Yes         20     200 3.414772
## 71    2pm Female       NA     61        Yes         20     135 3.239071
## 72   10am Female 3.367296     69        Yes          8     125 2.915606
## 73   10am   Male 3.526361     70        Yes         15     275 3.675034
## 74  other Female 3.931826     68        Yes         10     207 3.449035
## 75   11am   Male 3.258097     69        Yes          5     150 3.097837
## 76    1pm   Male 3.218876     73        Yes         10     185 3.194993
## 77   12pm Female 4.110874     66        Yes         10     165 3.282038
## 78   11am Female       NA     71        Yes         20      NA       NA
## 79   12pm Female 3.178054     66        Yes         10     170 3.312002
## 80    8am Female       NA     68        Yes         20      NA       NA
## 81         Male 3.610918     70        Yes         15     235 3.518091
## 82   10am   Male 4.043051     82        Yes         15     195 3.015045
## 83    8am Female 4.043051     67        Yes         10     188 3.382354
## 84   10am Female 4.007333     62        Yes         12     185 3.521348
## 85    9am Female 3.806662     68        Yes         10     165 3.222469
## 86    9am Female 3.610918     64        Yes          4     150 3.248046
## 87   12pm Female 3.637586     64        Yes         20     180 3.430433
## 88   10am Female 3.218876     67        Yes         10     178 3.327910
## 89    9am Female 3.465736     NA        Yes          5     135       NA
## 90    8am   Male 3.465736     71        Yes         15     187 3.261169
## 91    7am   Male 3.496508     68        Yes         20     180 3.309448
## 92   11am Female 3.761200     69        Yes         10     238 3.559340
## 93    8am Female 3.555348     64        Yes         30      NA       NA
## 94   10am Female 3.295837     62        Yes         20      NA       NA
## 95    8am   Male 3.367296     70        Yes         20     188 3.294725
## 96   10am Female 3.218876     65        Yes          5     115 2.951258
## 97    8am Female 4.007333     67        Yes         30      NA       NA
## 98   11am Female 3.178054     68        Yes         10     140 3.057768
## 99    7am Female 3.688879     68        Yes         25      NA       NA
## 100   7am Female 3.091042     64        Yes         15     162 3.325036
## 101   7am Female 3.258097     62        Yes         15     138 3.228430
## 102   2pm Female 2.995732     67        Yes          7     120 2.933325
## 103   2pm Female 3.912023     68        Yes         20      NA       NA
## 104  10am Female 3.951244     64        Yes         12     208 3.575151
## 105  10am Female 3.091042     62        Yes         20     150 3.311637
## 106  10am Female 3.091042     64        Yes         20     170 3.373484
## 107   8am Female 3.610918     66        Yes          6     140 3.117507
## 108  11am   Male 3.465736     75        Yes         16     185 3.140698
## 109   8am   Male 3.218876     70        Yes         15     170 3.194173
## 110  12pm Female 3.951244     63        Yes         16     185 3.489513
## 111  10am   Male 4.007333     72        Yes         10     210 3.349202
## 112  10am Female 3.332205     67        Yes          5      NA       NA
## 113   8am Female       NA     64        Yes          7     145 3.214466
## 114   8am Female 3.555348     70        Yes         20     240 3.538928
## 115  11am   Male 3.688879     70        Yes          5     215 3.429137
## 116   8am Female 3.465736     65        Yes         10     157 3.262701
## 117   7am Female 3.737670     67        Yes         15     201 3.449352
## 118   8am Female 4.158883     64        Yes         10     145 3.214466
## 119   8am Female 3.091042     66        Yes          9     142 3.132010
## 120   8am Female 3.178054     68        Yes         40     170 3.252311
## 121  11am   Male 3.891820     66        Yes         15     138 3.103240
## 122   8am Female 3.713572     62        Yes         15     187 3.532226
```

```
## 123   8am Female 3.688879     64        Yes          35     130 3.105035
## 124  10am Female 3.465736     69        Yes          15     195 3.360028
## 125  10am Female 3.135494     65        Yes           6      NA       NA
## 126  10am   Male 3.555348     70        Yes          10     273 3.667911
## 127  11am Female 3.135494     68        Yes           5     145 3.092859
## 128   7am   Male 3.737670     69        Yes          10     210 3.434310
## 129   8am Female 3.218876     64        Yes          20     133 3.128075
## 130 other   Male 3.218876     75        Yes          15     175 3.085116
## 131   9am Female 3.433987     70        Yes          40     215 3.429137
## 132   8am Female 2.944439     69        Yes          15     145 3.063858
## 133  10am Female 3.433987     NA        Yes           5     185       NA
## 134   9am Female 3.496508     65        Yes          10     165 3.312366
## 135   8am Female 3.295837     63        Yes          30     183 3.478467
## 136  11am Female 3.178054     66        Yes          10     140 3.117507
## 137   9am Female 3.258097     64        Yes           7     125 3.065725
## 138   2pm   Male 3.555348     74        Yes          25     230 3.385407
## 139  10am Female 3.135494     70        Yes          20     158 3.121042
## 140   8am Female 3.526361     61        Yes           5     123 3.145875
## 141   9am Female 3.258097     71        Yes          20     305 3.750210
## 142   8am   Male 3.258097     72        Yes          40     280 3.636796
## 143  10am   Male 3.091042     71        Yes          25     215 3.400530
## 144  11am   Male 3.044522     71        Yes          10     168 3.154017
## 145   8am Female 3.332205     65        Yes          10      NA       NA
## 146  10am Female 3.465736     67        Yes          15     165 3.251924
## 147  11am Female 3.295837     66        Yes          15      NA       NA
## 148 other        3.401197     65        Yes           5     155 3.249987
## 149  11am   Male 3.555348     77        Yes          10     220 3.261552
##     Vig.ex.Time Mod.ex.time Walk.ex.Time Total_Met_Min beg_weight  Beg_BMI
## 1           180         160          100            81        106 19.38554
## 2            40           0            0           103        145 24.12663
## 3            40          20           10           129        170 25.10187
## 4           180         180            0            71        170 23.05363
## 5            90          40            0           177         NA       NA
## 6             0         150           20           156         NA       NA
## 7            60          30           80           174        140 25.60354
## 8             0          40           30            87        152 18.99662
## 9            90           0          140            14        140 24.79718
## 10           50         160          125            36        195 29.64641
## 11            0          75           45           132         NA       NA
## 12           45           0          420            55        215 29.15606
## 13            0          40          105           140        258 34.98727
## 14            0           0           10           106        165 24.36358
## 15           90          60           60            12        189 30.50207
## 16          225         360           70           111        194 27.83306
## 17           90          60          420            78        124 21.96321
## 18            0          30          100           133        103 22.28655
## 19            0           0           30           183         NA       NA
## 20          180           0            0            35        125 21.45386
## 21            0          30           50            95         NA       NA
## 22          210         210          105            97        185 23.12089
## 23            0         120          120           176         NA       NA
## 24            0           0           60            64        120 22.67132
## 25            0           0           49            45        100 18.28824
## 26           20           0           20            76         NA       NA
```

```
## 27  300  80  189  108  139 25.42066
## 28  100  60   90   26  165 24.36358
## 29   75   0   20  156  103 17.13822
## 30  300 300   60  122  115 19.73755
## 31   60   0   90  163   NA       NA
## 32  160  60   80   56  125 21.45386
## 33    0   0   68   75  175 26.60575
## 34  180  30  100   61  125 21.45386
## 35  120  30  600  101  168 26.30965
## 36    0   0   35   11  172 32.49557
## 37   30  60  100  166  130 21.63077
## 38    0  90  150  173   NA       NA
## 39    0   0  140  134  259 44.45239
## 40  180  91   70   67  124 21.96321
## 41   60 180   60   33  142 20.96744
## 42    0 1680    0  150  103 18.24364
## 43  150 150   90   69  150 23.49076
## 44   60  50  150   13   NA       NA
## 45    0 120    0  136  130 20.98026
## 46    0   0   20  155   NA       NA
## 47  180  75   35   60   NA       NA
## 48    0   0  420   32  163       NA
## 49  160   0  420   91  155       NA
## 50   80   0   60  171  165 24.36358
## 51  160   0    0   21  220 29.83410
## 52    0  20   80  109  149 27.24948
## 53    0  60   60  130  135 21.14168
## 54    0   9    0  113  207 41.80437
## 55   60 210   60   38  140 27.33889
## 56   80   0    0  153   NA       NA
## 57    0 135    0  144   NA       NA
## 58    0   0  120  125  125 19.57563
## 59  360   0    0   98   NA       NA
## 60   15  10    0   42   NA       NA
## 61   16  16   90  135   NA       NA
## 62    0   0  135  131   NA       NA
## 63   90  40   30  182  134 25.31631
## 64  315  60   16   94  205 36.31015
## 65    0   0  210  158  118 19.04362
## 66  180 180    0   71  200 29.53161
## 67  200 240  140  100  210 28.47801
## 68   60  60   60  178  195 25.72434
## 69    0   0  210  158  186       NA
## 70    0 100   60  149  180 27.36592
## 71   40  30  280   29  115 21.72669
## 72   90   9    9  164  117 17.27599
## 73  200  60    0   58  260 37.30204
## 74    0   0  225  162  197 29.95048
## 75    0  30   30   72  145 21.41042
## 76  180 150   50   74  175 23.08594
## 77    0   0  210  158  155 25.01492
## 78    0  20   60   93   NA       NA
## 79    0 240   60   12  160 25.82185
## 80   90  60   20    6   NA       NA
```

```
## 81   120  120   60   46  220 31.56327
## 82     0  140   75  165  180 18.81916
## 83     0   60    0   80  178 27.87570
## 84   225    0  140   77  173 31.63866
## 85    60   30  210   23  155 23.56510
## 86     0   90  140  169  146 25.05811
## 87   120  120   80   51  160 27.46094
## 88     0   45   90  135  168 26.30965
## 89     0    0   30  183  130       NA
## 90   135   30   24   20  172 23.98651
## 91   180  180    0   71  160 24.32526
## 92   165   90  225   82  228 33.66604
## 93     0    0  120  125   NA       NA
## 94     0    0   60   64   NA       NA
## 95     0   60   90  143  168 24.10286
## 96     0   15    0  150  110 18.30296
## 97     0  225  300   61   NA       NA
## 98     0    0   60   64  130 19.76427
## 99   120  105  140   59   NA       NA
## 100  225  210  420  127  147 25.22974
## 101   60    0   60  157  123 22.49454
## 102  180  180    0   71  113 17.69637
## 103    0   90   60  147   NA       NA
## 104    0   60  300   17  196 33.63965
## 105    0  360  120   57  130 23.77471
## 106    0    0   80   89  150 25.74463
## 107    0    0  480   41  134 21.62580
## 108   12   16  210  172  169 21.12124
## 109    0  135   20  152  155 22.23776
## 110    0  140  140    5  169 29.93374
## 111   60  120    0  180  200 27.12191
## 112  240   40  120   83   NA       NA
## 113  120  100  100   50  138 23.68506
## 114  240  120   40   86  220 31.56327
## 115    0   30   40   85  210 30.12857
## 116   60    0    0  136  147 24.45941
## 117    0    0  100  107  186 29.12854
## 118    8   56   20   93  135 23.17017
## 119  200   40   75   65  133 21.46442
## 120    0    0  120  125  130 19.76427
## 121  360  120  120  121  123 19.85055
## 122   45  240  210   66  172 31.45578
## 123    0   40  150  154   95 16.30493
## 124  180  210  300  104  180 26.57845
## 125   30   45  360   44   NA       NA
## 126    0    0  210  158  263 37.73245
## 127   50   75  135   10  140 21.28460
## 128   30   60   20  145  200 29.53161
## 129  135   90  160   63  113 19.39429
## 130   30   45   20  137  160 19.99644
## 131    0    0   80   89  175 25.10714
## 132  240  120  210  102  130 19.19555
## 133  360    0  240  116  180       NA
## 134    0    0  160  142  155 25.79053
```

```
## 135           0          30           15           49        153 27.09977
## 136         180          20            0           39        130 20.98026
## 137           0         240          300           62        118 20.25244
## 138         135         105          210           73        205 26.31757
## 139         180          20           60           53        138 19.79878
## 140         120          40           40           18        118 22.29347
## 141          75           0            0          151        285 39.74509
## 142         240          30            0           68        240 32.54630
## 143          60          90           40          181        190 26.49673
## 144         480         240           60          139        158 22.03412
## 145          90          90          105           34         NA       NA
## 146           0           0          315            7        150 23.49076
## 147           0           0          140          134         NA       NA
## 148         480           0            0          124        150 24.95858
## 149           0           0          180          148        210 24.89965
##     BMIChange weightgain.b
## 1   -16.26405            1
## 2   -20.90296            1
## 3   -21.82171            1
## 4   -19.80442            1
## 5          NA            1
## 6          NA            1
## 7   -22.25891            1
## 8   -16.00089            1
## 9   -21.51740            1
## 10  -26.20695            1
## 11         NA            1
## 12  -25.69439            1
## 13  -31.28819            1
## 14  -21.05596            1
## 15  -26.98368            1
## 16  -24.45650            1
## 17  -18.83426            1
## 18  -19.08992            1
## 19         NA            1
## 20  -18.27455            1
## 21         NA            0
## 22  -19.78441            1
## 23         NA            1
## 24  -19.43225            1
## 25  -15.19947            1
## 26         NA            1
## 27  -21.98377            1
## 28  -21.14071            1
## 29  -14.24952            1
## 30  -16.71226            1
## 31         NA            1
## 32  -18.33326            1
## 33  -23.19098            1
## 34  -18.34882            1
## 35  -23.01048            1
## 36  -28.85378            1
## 37  -18.51903            1
## 38         NA            1
```

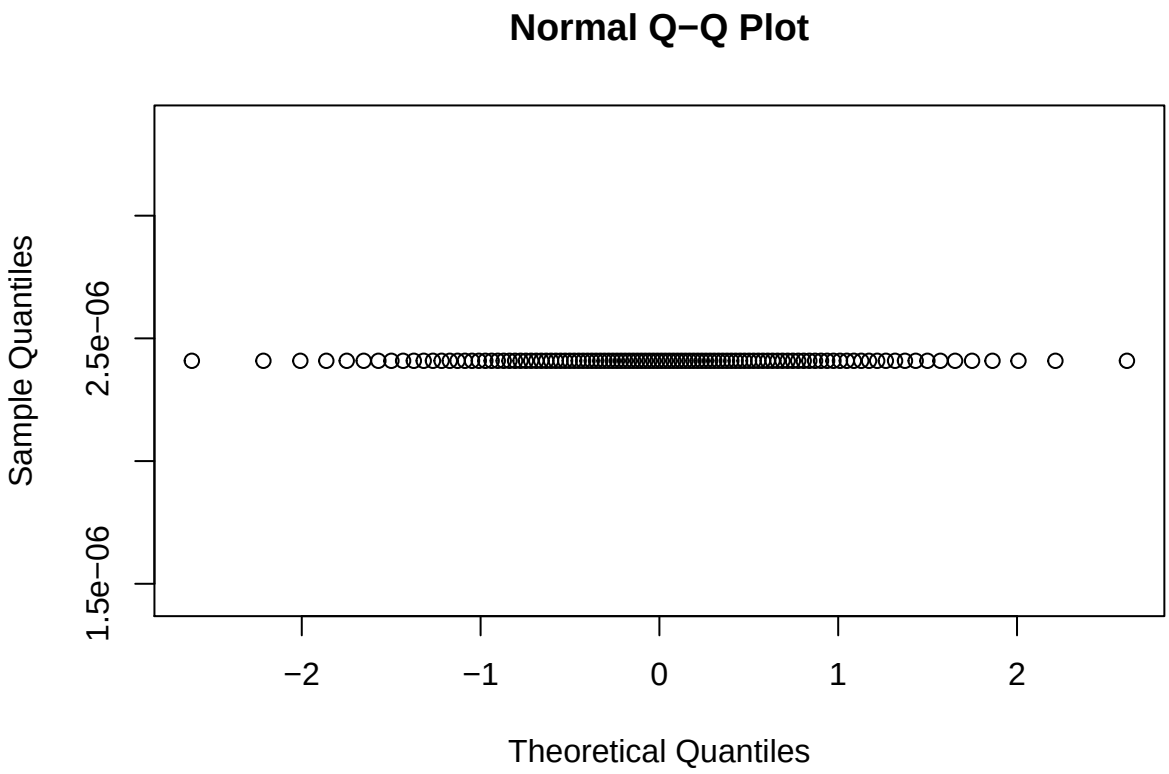
```
## 39  -40.62006           1
## 40  -18.81133           1
## 41  -17.86961           1
## 42  -15.20389           1
## 43  -20.30151           1
## 44         NA           1
## 45  -17.86275           1
## 46         NA           1
## 47         NA           1
## 48         NA           1
## 49         NA           1
## 50  -21.08342           1
## 51  -26.31069           1
## 52  -23.83044           1
## 53  -17.95244           1
## 54  -38.02428           1
## 55  -23.83634           1
## 56         NA           1
## 57         NA           1
## 58  -16.45282           1
## 59         NA           1
## 60         NA           1
## 61         NA           1
## 62         NA           1
## 63  -22.04827           1
## 64  -32.58157           1
## 65  -16.01542           1
## 66  -26.05099           1
## 67  -24.95459           1
## 68  -22.45173           1
## 69         NA           1
## 70  -23.95115           1
## 71  -18.48762           1
## 72  -14.36039           1
## 73  -33.62701           1
## 74  -26.50144           1
## 75  -18.31258           1
## 76  -19.89095           1
## 77  -21.73288           1
## 78         NA           1
## 79  -22.50985           1
## 80         NA           1
## 81  -28.04517           1
## 82  -15.80411           1
## 83  -24.49334           1
## 84  -28.11731           1
## 85  -20.34263           1
## 86  -21.81006           1
## 87  -24.03050           1
## 88  -22.98174           1
## 89         NA           1
## 90  -20.72534           1
## 91  -21.01581           1
## 92  -30.10670           1
```

```
## 93         NA           1
## 94         NA           1
## 95  -20.80813           1
## 96  -15.35170           1
## 97         NA           1
## 98  -16.70651           1
## 99         NA           1
## 100 -21.90470           1
## 101 -19.26611           1
## 102 -14.76304           1
## 103        NA           1
## 104 -30.06450           1
## 105 -20.46308           1
## 106 -22.37115           1
## 107 -18.50830           1
## 108 -17.98055           1
## 109 -19.04358           1
## 110 -26.44422           1
## 111 -23.77271           1
## 112        NA           1
## 113 -20.47059           1
## 114 -28.02434           1
## 115 -26.69943           1
## 116 -21.19671           1
## 117 -25.67918           1
## 118 -19.95570           1
## 119 -18.33241           1
## 120 -16.51196           1
## 121 -16.74731           1
## 122 -27.92355           1
## 123 -13.19990           1
## 124 -23.21842           1
## 125        NA           1
## 126 -34.06454           1
## 127 -18.19174           1
## 128 -26.09730           1
## 129 -16.26621           1
## 130 -16.91133           1
## 131 -21.67801           1
## 132 -16.13169           1
## 133        NA           1
## 134 -22.47817           1
## 135 -23.62131           1
## 136 -17.86275           1
## 137 -17.18672           1
## 138 -22.93216           1
## 139 -16.67773           1
## 140 -19.14759           1
## 141 -35.99488           1
## 142 -28.90950           1
## 143 -23.09620           1
## 144 -18.88010           1
## 145        NA           1
## 146 -20.23883           1
```

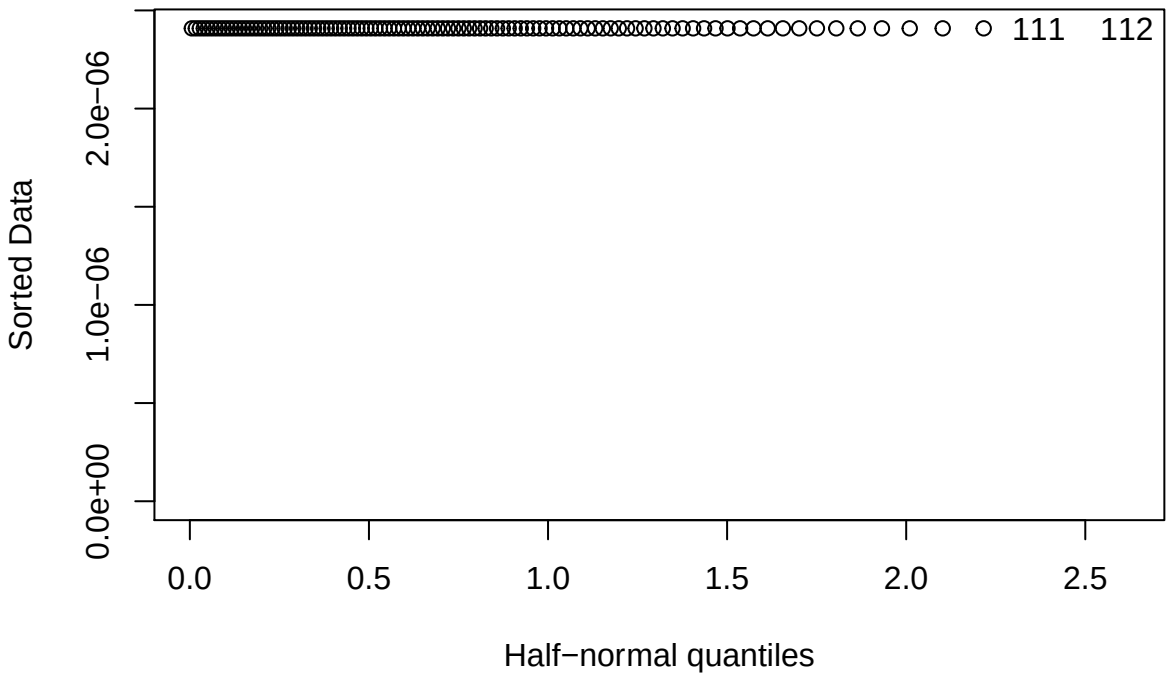
```
## 147        NA            1
## 148 -21.70859            1
## 149 -21.63809            1
```

```
##   Snumber Date_Started     dept         Job shift gender Age height head
## 1       1     4/6/2005 Training       Other   8am Female  30     66    3
## 2       2    4/10/2005 Training       Other   7am Female  31     65    0
## 3       3    4/11/2005 Training       Other   8am Female  26     62    0
## 4       4    4/11/2005 Training       Other   7am Female  34     62    5
## 5       5    4/11/2005       CS       Other   9am Female  27     65    0
## 6       6    4/14/2005      CFS Collections  11am   Male  21     74    0
##   neck rshoul relbow rwrist lback rleg rknee rfoot eyes uback lshould
## 1    5      5      0      0     5    0     0     0    3     5       5
## 2    5      0      0      0     4    0     4     0    0     0       0
## 3    3      3      0      3     1    0     0     0    4     3       3
## 4    5      4      2      3     0    0     2     1    4     0       0
## 5    0      0      0      0     1    0     0     0    2     0       0
## 6    0      0      0      1     1    0     0     0    1     0       0
##   lelbow lwrist butt lleg lknee lfoot ddis ddiscomfort     oftendis
## 1      0      0    0    0     0     0   NA     #VALUE! Occasionally
## 2      0      0    0    0     0     0   NA     #VALUE!  When Active
## 3      0      3    0    0     0     0  730         730  When Active
## 4      0      1    0    0     2     1  365         365 Occasionally
## 5      0      0    0    0     0     0   NA     #VALUE! Occasionally
## 6      1      0    0    0     0     0  182         182 Occasionally
##            discomorig             workplace1       Job1       tool
## 1 Gradually over time                Seating No Concern No Concern
## 2 Gradually over time                Reaches No Concern No Concern
## 3 Gradually over time Adjustability; Seating     Breaks
## 4 Gradually over time             No Concern No Concern No Concern
## 5 Gradually over time             No Concern    Methods No Concern
## 6 Gradually over time             No Concern     Breaks No Concern
##                       handling                                environment
## 1                      Lifting                                Temperature
## 2 Carrying; Lifting; Push/Pull        Temperature; Lighting; Ventilation
## 3        Lifting; Lift Assists        Ventilation; Lighting; Temperature
## 4            Carrying; Lifting                          Temperature; Noise
## 5                   No Concern                                   Lighting
## 6                   No Concern Noise; Temperature; Lighting; Ventilation
##   fatigue5min fatigue2 fatigue4 fatigue6 fatigue8 fatigue10 fatigue12
## 1           5        3        3        3        3         3         4
## 2           0        1        2        5        5        NA        NA
## 3           1        2        3        3        4         0         0
## 4           4        2        0        2        2        NA        NA
## 5           0        0        0        3        1         2         4
## 6           0        0        0        0        0         0         0
##   Days_to_less_fatigue injury                          injurypart
## 1                 14.0     No
## 2                 30.0    Yes
## 3                 60.0    Yes Neck; Hand/wrist; Lower Back; Foot
## 4                  1.5    Yes                               Neck
## 5                   NA     No
## 6                   NA     No
##        plabor prevposition weightgain lbs_gained pounds_gained
```

```
## 1 Very little           No         No         NA       #VALUE!
## 2    Moderate           No         No         NA       #VALUE!
## 3    Moderate           No        Yes         18            18
## 4    Moderate           No        Yes         NA       #VALUE!
## 5 Very little           No        Yes          6             6
## 6 Very little           No         No         NA       #VALUE!
##             weight_situation bweight exbreak expartic numstretch member
## 1    I am AT my ideal weight     135     Yes       No        0.0    Yes
## 2 I am ABOVE my ideal weight     135      No       No        0.0     No
## 3 I am ABOVE my ideal weight     124     Yes      Yes        0.0     No
## 4 I am ABOVE my ideal weight      NA     Yes      Yes        0.0     No
## 5 I am ABOVE my ideal weight     151     Yes      Yes        1.5     No
## 6 I am ABOVE my ideal weight     280     Yes      Yes        2.0     No
##   daysVHW Veg_Serv fruit_servings fried_servings vigorous7 vigur vigoroust
## 1     3.5       NA             NA             NA       5.5    NA        60
## 2     0.0        2              0              0       3.0    NA        30
## 3     0.0        3              5              2       3.0    NA        60
## 4      NA        2              2              0       3.0    NA        NA
## 5     0.0        2              3              2       2.0    NA        20
## 6     0.0        0              0              0       3.0    NA       120
##   vigtur moderate7 modur moderatet modtur walk7 walkur walkt walktur
## 1     NA         0    NA         0     NA     0     NA     0      NA
## 2     NA         0    NA         0     NA     3     NA    60      NA
## 3     NA         4    NA        40     NA     5     NA    20      NA
## 4      8         7    NA        NA      8     3     NA    NA       8
## 5     NA         0    NA         0     NA     0     NA     0      NA
## 6     NA         3    NA        60     NA     7     NA    90      NA
##   sitt7t situr Field66   BMI Total_ex_time Total_Ex_Time_Exclude
## 1     NA     8       1 21.79           330                    NA
## 2    300    NA       2 22.46           270                    NA
## 3    600    NA       3 22.68           440                    NA
## 4    240    NA       4    NA           104                    NA
## 5    540    NA       5 25.12            40                    NA
## 6    600    NA       6 35.95            NA                  1170
##   Vig.ex.Time Mod.ex.time Walk.ex.Time Total_Met_Min Total_Exclude_Met
## 1         330           0            0          2640                NA
## 2          90           0          180          1314                NA
## 3         180         160          100          2410                NA
## 4          24          56           24                              NA
## 5          40           0            0           320                NA
## 6         360         180          630                             5679

## Warning: glm.fit: algorithm did not converge
```




```
## Warning: package 'faraway' was built under R version 3.6.3
```




```
## Warning: glm.fit: algorithm did not converge
```

```
##
## Call:
## glm(formula = weightgain.b ~ shift + gender + Age + height +
##     Beg_BMI + Total_Met_Min, family = binomial, data = na.omit(dat1))
##
## Deviance Residuals:
##       Min         1Q     Median         3Q        Max
## 2.409e-06  2.409e-06  2.409e-06  2.409e-06  2.409e-06
##
## Coefficients:
##                 Estimate Std. Error z value Pr(>|z|)
## (Intercept)    2.657e+01  9.919e+05       0        1
## shift10am     -4.695e-06  2.728e+05       0        1
## shift11am     -2.580e-06  2.789e+05       0        1
## shift12pm      1.584e-07  2.974e+05       0        1
## shift1pm      -8.091e-07  3.662e+05       0        1
## shift2pm      -2.699e-06  3.245e+05       0        1
## shift7am      -5.463e-06  2.889e+05       0        1
## shift8am      -1.577e-06  2.691e+05       0        1
## shift9am      -1.728e-06  2.820e+05       0        1
## shiftother    -5.322e-07  3.117e+05       0        1
## genderFemale  -9.812e-08  3.916e+05       0        1
## genderMale     9.053e-07  4.036e+05       0        1
```

```
## Age           -1.096e-06  1.174e+05       0        1
## height        -1.187e-07  1.186e+04       0        1
## Beg_BMI       -1.285e-07  6.968e+03       0        1
## Total_Met_Min -1.341e-10  7.348e+02       0        1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 0.0000e+00  on 111  degrees of freedom
## Residual deviance: 6.4978e-10  on  96  degrees of freedom
## AIC: 32
##
## Number of Fisher Scoring iterations: 25
```

```
##
## Call:
## glm(formula = weightgain.b ~ gender + Age + height + Beg_BMI +
##     Total_Met_Min, family = binomial, data = na.omit(dat1))
##
## Deviance Residuals:
##       Min         1Q     Median         3Q        Max
## 2.409e-06  2.409e-06  2.409e-06  2.409e-06  2.409e-06
##
## Coefficients:
##                 Estimate Std. Error z value Pr(>|z|)
## (Intercept)    2.657e+01  9.572e+05       0        1
## genderFemale  -1.074e-08  3.593e+05       0        1
## genderMale    -8.714e-09  3.693e+05       0        1
## Age            3.807e-09  1.138e+05       0        1
## height        -3.932e-11  1.167e+04       0        1
## Beg_BMI        1.322e-10  6.518e+03       0        1
## Total_Met_Min -2.871e-11  6.991e+02       0        1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 0.0000e+00  on 111  degrees of freedom
## Residual deviance: 6.4978e-10  on 105  degrees of freedom
## AIC: 14
##
## Number of Fisher Scoring iterations: 25
```

```
## Analysis of Deviance Table
##
## Model 1: weightgain.b ~ gender + Age + height + Beg_BMI + Total_Met_Min
## Model 2: weightgain.b ~ shift + gender + Age + height + Beg_BMI + Total_Met_Min
##   Resid. Df Resid. Dev Df Deviance Pr(>Chi)
## 1       105 6.4978e-10
## 2        96 6.4978e-10  9        0        1
```

Solely from the model, we can see that only three variables have significant impact on the predictor: gender, Beg_BMI and Total_Met_Min. We perform a Chi-sqaure test to test if the model contains shift is better than the model without shifts. The null hypothesis is that the model without shift is a better model, and the alternative hypothesis is that the model without shift is not a better model. In order to compare two models, we omit the NA values in the dataset to make sure the number of cases used in each model is the

same. The test statistic is is very large given a 95% confidence interval, therefore we fail to reject the null hypothesis that the reduced model is better, which means that the model contains shift is less favorable than the reduced model. The test result is shown below:

Analysis of Deviance Table

Model 1: weightgain.b ~ gender + Age + height + Beg_BMI + Total_Met_Min Model 2: weightgain.b ~ shift + gender + Age + height + Beg_BMI + Total_Met_Min Resid. Df Resid. Dev Df Deviance Pr(>Chi)
1 202 236.06
2 194 228.44 8 7.6207 0.4714

Since the initial model shows that Total_Met_Min is a significant variable, we performed another analysis, using a forward stepwise selection to select the model with the most appropriate variables that produces the lowest AIC. The selected variables are exactly the same as our previous analysis, which are gender, Beg_BMI and Total_Met_Min, which reassures that total metabolic minutes do have an effect on weight gain and shift does not have an effect on weightgain. The results are shown below:

Call: glm(formula = weightgain.b ~ gender + Beg_BMI + Total_Met_Min, family = binomial, data = na.omit(dat1))

Coefficients: (Intercept) genderMale Beg_BMI Total_Met_Min
3.0281421 -0.7079166 -0.0615582 -0.0001601

Degrees of Freedom: 207 Total (i.e. Null); 204 Residual Null Deviance: 251.7 Residual Deviance: 237.4 AIC: 245.4

```
## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: algorithm did not converge

##   Step Df Deviance Resid. Df   Resid. Dev AIC
## 1      NA       NA       111 6.497771e-10   2

##
## Call:  glm(formula = weightgain.b ~ 1, family = binomial, data = na.omit(dat1))
##
## Coefficients:
## (Intercept)
##       26.57
##
## Degrees of Freedom: 111 Total (i.e. Null);  111 Residual
## Null Deviance:       0
## Residual Deviance: 6.498e-10     AIC: 2
```

The Relationship Between Total Metabolic Minutes and Weight Gain

Using various methods of analysis, we found that total metabolic minutes is a significant variable. The initial model demonstrated that there is a negative relationship between total metabolic minutes and weight gain, and this was corroborated by the subsequent forward stepwise model.

The Relationship Between Shift Time and Weight Gain

It does not appear that shift has significant impact on weight gain. From the Chi-square test, we found that the model without shift performs better than the model with shift. As mentioned, we failed to reject the null hypothesis that the reduced model is better, so we do not find it beneficial to include shift in our final model to predict weight gain.

Conclusion

Our initial goal was to see whether shift and total metabolic minutes have an impact on weight gain. Multiple forms of analysis indicate that shift is not a relevant factor in determining weight gain, while total metabolic minutes is. Total metabolic minutes has a slightly adverse relationship to weight gain. We conducted further analysis to go beyond the requested covariate relationships. For a final model selection, gender, Beg_BMI, and Total_Met_Min appear to be the most signficant and useful predictors of weight gain.