biostats_final_combined

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Descriptive summary statistics for all variables

Two table with summary information on the descriptive statistics of all variables are listed below. The frequency and percentage of each categories in each categorical variable is listed out. For each numeric variable, the table includes values of mean, median, standard deviation, minimum, maximum, Q1 and Q3 values.

Categorical Variables

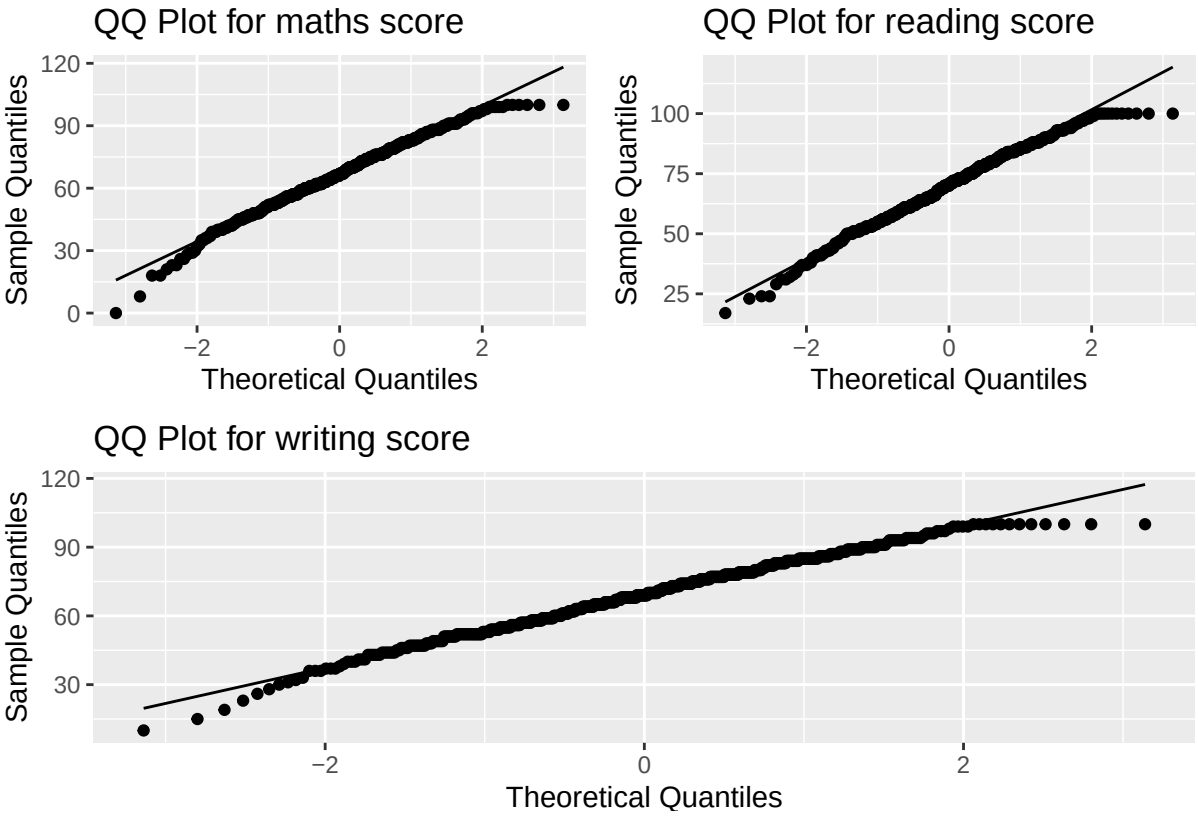
variable	category	count	percent
gender	female	315	53.662692
gender	male	272	46.337308
ethnic_group	group A	50	8.517888
ethnic_group	group B	123	20.954003
ethnic_group	group C	174	29.642249
ethnic_group	group D	155	26.405451
ethnic_group	group E	85	14.480409
parent_educ	associate's degree	128	21.805792
parent_educ	bachelor's degree	71	12.095400
parent_educ	high school	122	20.783646
parent_educ	master's degree	39	6.643952
parent_educ	some college	116	19.761499
parent_educ	some high school	111	18.909710
lunch_type	free/reduced	206	35.093697
lunch_type	standard	381	64.906303
test_prep	completed	208	35.434412
test_prep	none	379	64.565588
parent_marital_status	divorced	92	15.672913
parent_marital_status	married	343	58.432709
parent_marital_status	single	137	23.339012
parent_marital_status	widowed	15	2.555366
practice_sport	never	68	11.584327
practice_sport	regularly	218	37.137990
practice_sport	sometimes	301	51.277683
is_first_child	no	192	32.708688
is_first_child	yes	395	67.291312
transport_means	private	229	39.011925
transport_means	school_bus	358	60.988075
wkly_study_hours	< 5	154	26.235094
wkly_study_hours	> 10	104	17.717206
wkly_study_hours	5-10	329	56.047700

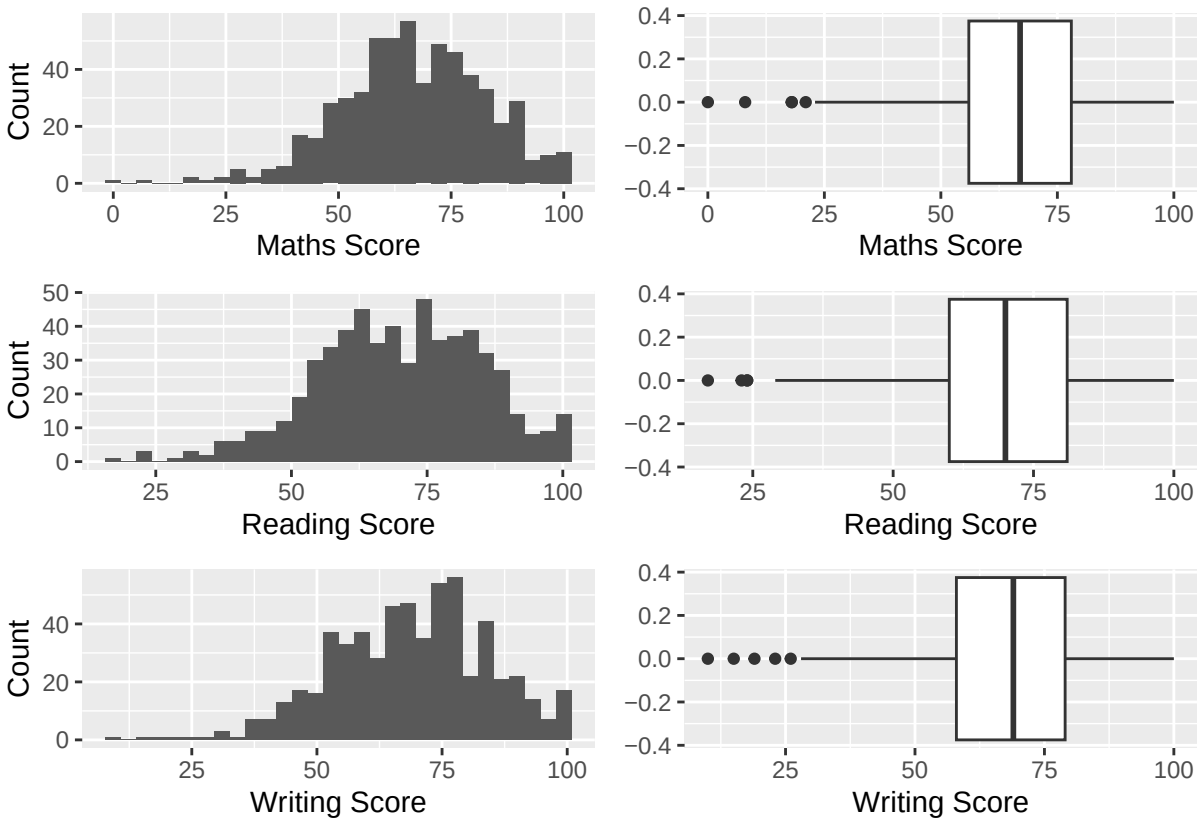
Numeric Variables

variable	mean	median	sd	minimum	maximum	q1	q3
nr_siblings	2.139693	2	1.481712	0	7	1	3
math_score	66.676320	67	16.113744	0	100	56	78
reading_score	69.846678	70	15.166662	17	100	60	81
writing_score	68.901192	69	15.550000	10	100	58	79

Distribution of the outcomes

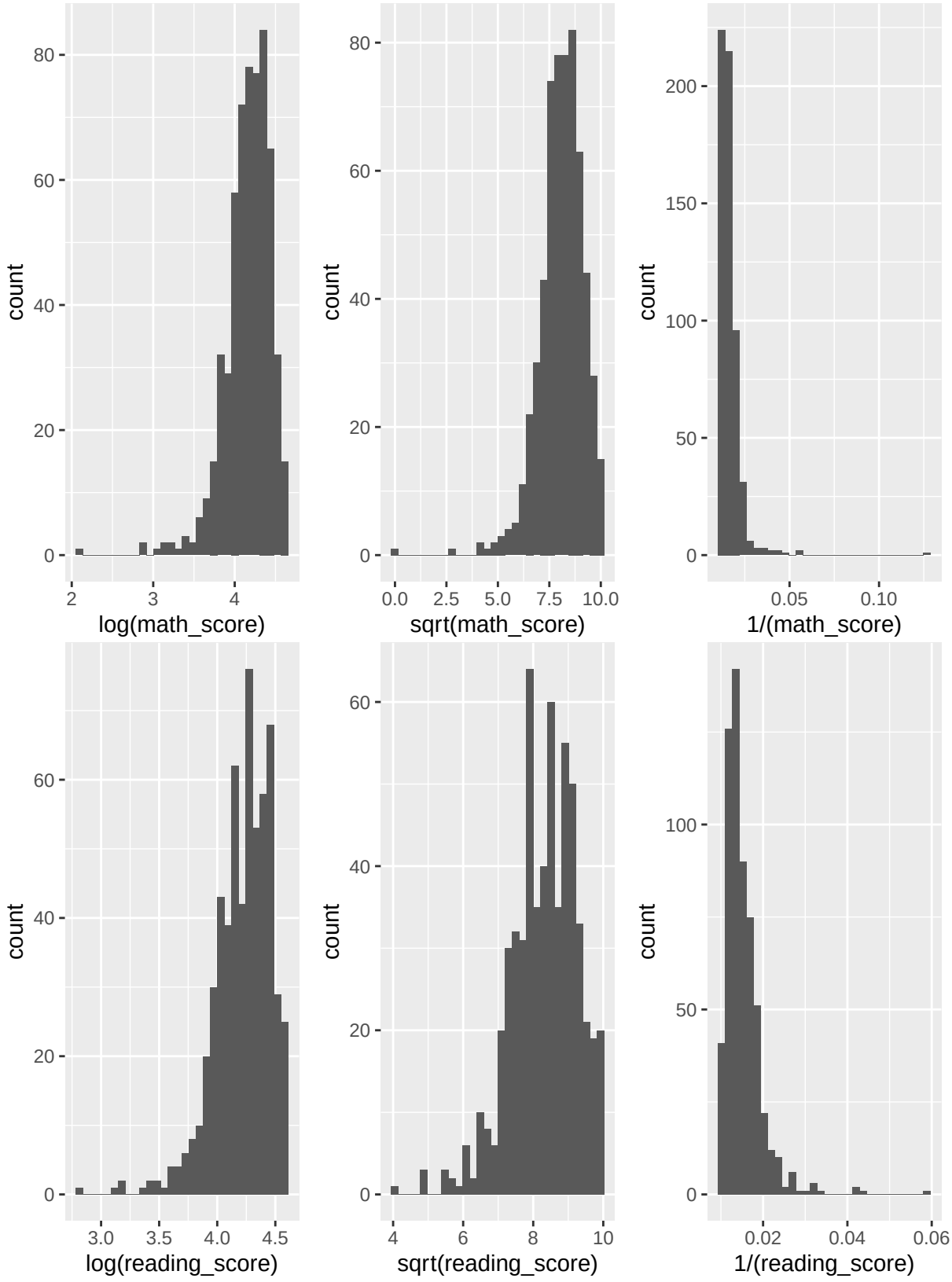
The outcome of this study includes the following variables: maths scores, reading scores, and writing scores. QQplots of the outcome variables are created to explore the distribution of each score. QQplot compares the quantiles of the data against the quantiles of a normal distribution. According the plots, majority of the data points of all three scores follow the straight qqline, which indicates they follow the normal distribution. However, there are some deviations from the line on the two ends of the distribution, which indicates the distributions might have heavier tails than normal distribution. Or, there might be skewness or outliers in the dataset. To further explore the distribution of outcomes, histograms and boxplots for the scores were incorporated. As suggested by the histograms and boxplots, all three scores are left-skewed with outliers on the left side of the distribution.

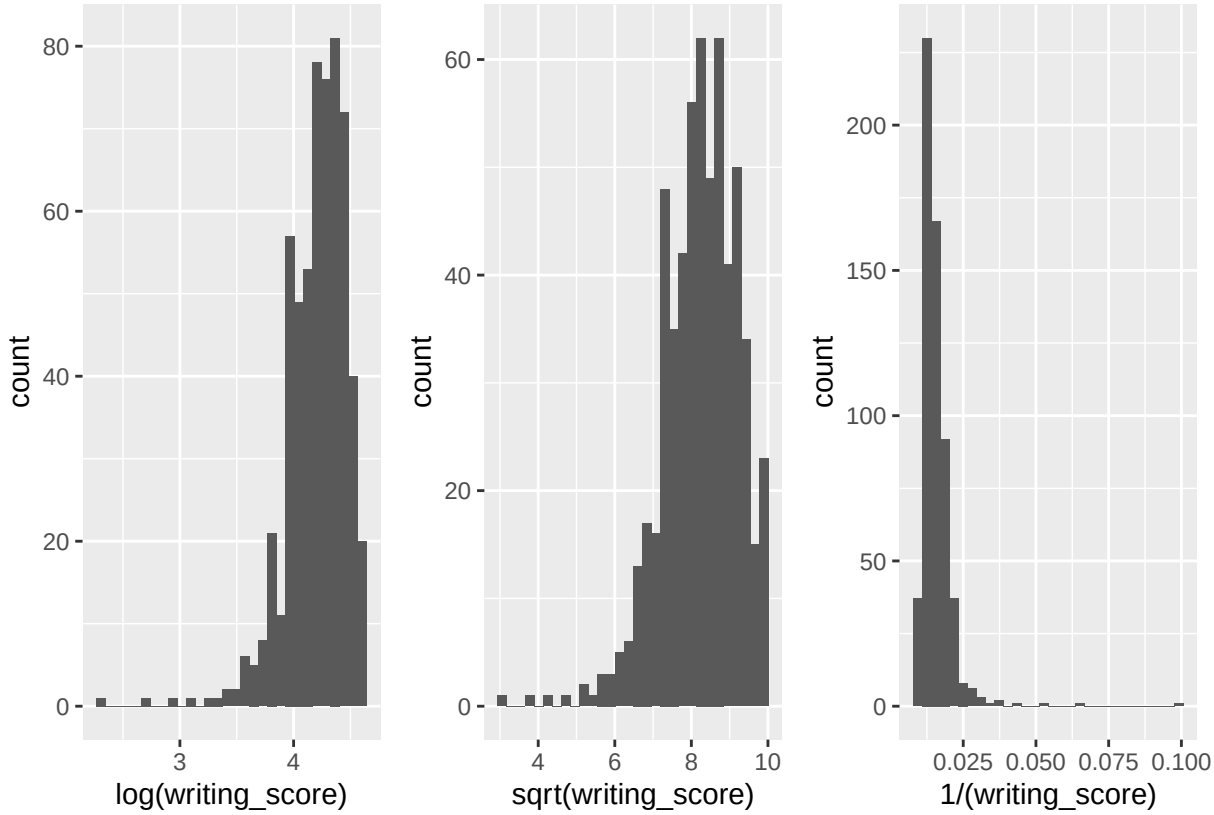




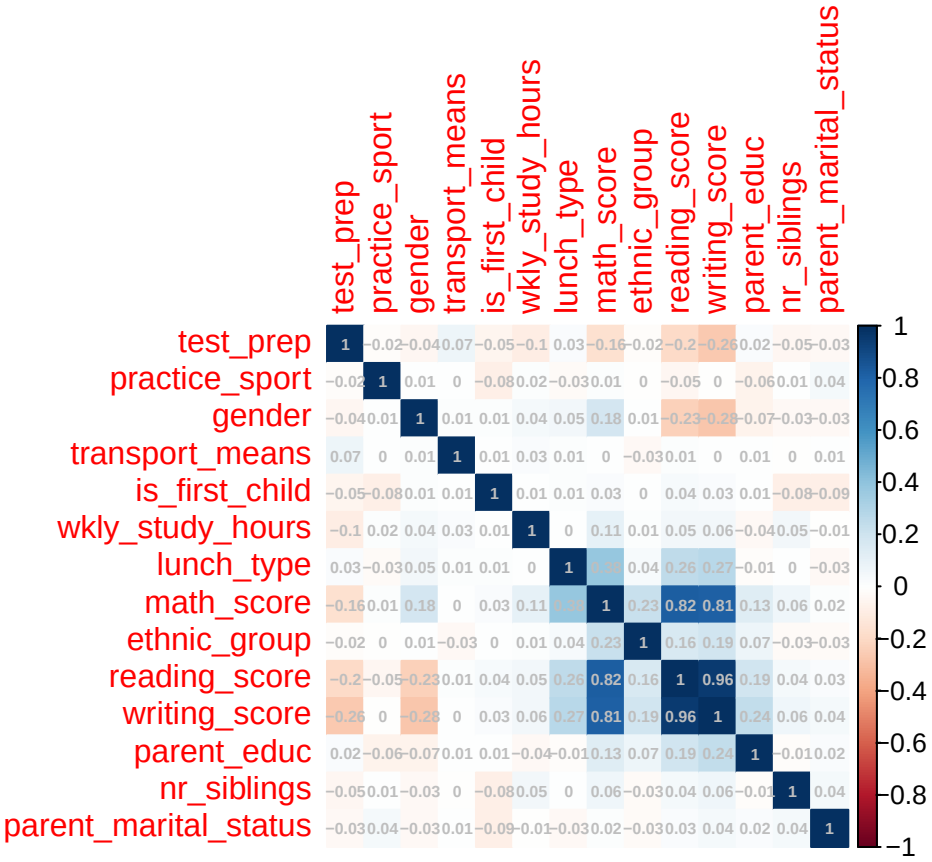
Potential transformations

Potential transformations that may help further prepare the variables for later analysis were tested. With the expectation to normalize distribution and minimize skewness and impact of outliers, three types of transformations were tested: 1) Natural logarithm 2) Square Root 3) Inverse. The resulting plots are plotted in histograms shown below. There is no apparent improvement on the distribution of the outcome through the three transformations mentioned. Thus, orignial outcome data were chosen to be used in following statistical modeling steps.


count
log(math_score)
sqrt(math_score)
1/(math_score)
log(reading_score)
sqrt(reading_score)
1/(reading_score)


count
80
60
40
20
0
3
4
log(writing_score)
count
60
40
20
0
4
6
8
10
sqrt(writing_score)
count
200
150
100
50
0
0.025
0.050
0.075
0.100
1/(writing_score)

Pairwise relationships



By plotting our the pairwise correlation between variables, there is apparent linearity among the three scores. Other correlation coefficients are relatively small, indicating weak linear relationship between the variables.

MLR lm()

MLR - Math

```
##
## Call:
## lm(formula = math_score ~ gender + ethnic_group + parent_educ +
##     lunch_type + test_prep + parent_marital_status + practice_sport +
##     is_first_child + nr_siblings + transport_means + wkly_study_hours,
##     data = df_transformed)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -48.916  -9.265   0.725  10.104  33.013
##
## Coefficients:
##                                Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     44.1006     3.6704  12.015  < 2e-16 ***
## gendermale                       5.0855     1.1386   4.467 9.61e-06 ***
## ethnic_groupgroup B             -0.1788     2.3136  -0.077  0.93841
## ethnic_groupgroup C             -0.2089     2.2149  -0.094  0.92489
```

```
## ethnic_groupgroup D             3.6247     2.2286   1.626  0.10441
## ethnic_groupgroup E            11.1752     2.4434   4.574 5.90e-06 ***
## parent_educhigh school         -0.3235     1.8015  -0.180  0.85757
## parent_educassociate's degree   4.9058     1.7728   2.767  0.00584 **
## parent_educsome college         3.1933     1.8163   1.758  0.07927 .
## parent_educbachelor's degree    6.6652     2.0763   3.210  0.00140 **
## parent_educmaster's degree      6.8096     2.5417   2.679  0.00760 **
## lunch_typestandard             12.3539     1.1771  10.495  < 2e-16 ***
## test_prepnone                  -4.7717     1.2007  -3.974 7.99e-05 ***
## parent_marital_statusmarried    5.4805     1.6170   3.389  0.00075 ***
## parent_marital_statussingle     2.1682     1.8454   1.175  0.24053
## parent_marital_statuswidowed    7.7944     3.8119   2.045  0.04134 *
## practice_sportsometimes         1.5255     1.8439   0.827  0.40838
## practice_sportregularly         1.6701     1.9046   0.877  0.38092
## is_first_childyes               1.1303     1.2125   0.932  0.35162
## nr_siblings                     0.7403     0.3844   1.926  0.05461 .
## transport_meansschool_bus      -0.4319     1.1629  -0.371  0.71050
## wkly_study_hours5-10            3.5394     1.3429   2.636  0.00863 **
## wkly_study_hours> 10            3.0384     1.7540   1.732  0.08378 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 13.52 on 564 degrees of freedom
## Multiple R-squared:  0.3221, Adjusted R-squared:  0.2956
## F-statistic: 12.18 on 22 and 564 DF,  p-value: < 2.2e-16
```

Coefficients and Significance Levels:

- Intercept (44.1006): The expected value of math_score when all other predictors are at their reference level or zero.
- gendermale (5.0855, $p < 0.001$): Being male is associated with an average increase of 5.0855 points in math_score compared to females, holding all else constant. This is statistically significant.
- ethnic_group: Only ethnic_groupgroup E (11.1752, $p < 0.001$) is significant, suggesting students in this group score higher in math compared to the reference group.
- parent_educ: The associate's degree (4.9058, $p = 0.00584$), bachelor's degree (6.6652, $p = 0.00140$), and master's degree (6.8096, $p = 0.00760$) are significant and associated with higher math scores compared to the reference category.
- lunch_typestandard (12.3539, $p < 0.001$): Students with standard lunch type score significantly higher.
- test_prepnone (-4.7717, $p < 0.001$): Not participating in test preparation is associated with lower math scores.
- parent_marital_status: Married (5.4805, $p = 0.00075$) and Widowed (7.7944, $p = 0.04134$) are associated with higher scores.
- practice_sport: Not significant.
- is_first_childyes: Not significant.
- nr_siblings (0.7403, $p = 0.05461$): A borderline significant positive association with math scores.
- transport_meansschool_bus: Not significant.
- wkly_study_hours: Studying 5-10 hours (3.5394, $p = 0.00863$) shows a significant positive effect.

Residuals:

The spread of residuals suggests the errors are somewhat symmetrically distributed around the predicted values, which is a good sign for linear regression assumptions.

Model Fit:

Residual Standard Error (13.52): Indicates the average difference between the observed values and the values predicted by the model.

R-squared:

- Multiple R-squared (0.3221): About 32.21% of the variability in math_score is explained by the model.
- Adjusted R-squared (0.2956): Adjusts the R-squared for the number of predictors, a better measure for models with multiple predictors.

Statistic & p-value

F-statistic (12.18) and p-value (< 2.2e-16): The model is statistically significant, meaning it performs better than a model with no predictors.

MLR - reading

```
##
## Call:
## lm(formula = reading_score ~ gender + ethnic_group + parent_educ +
##     lunch_type + test_prep + parent_marital_status + practice_sport +
##     is_first_child + nr_siblings + transport_means + wkly_study_hours,
##     data = df_transformed)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -41.754  -8.793   0.635   9.118  30.513
##
## Coefficients:
##                                Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     60.8028     3.5826  16.972  < 2e-16 ***
## gendermale                      -7.6725     1.1114  -6.904 1.37e-11 ***
## ethnic_groupgroup B             -1.4287     2.2582  -0.633 0.527220
## ethnic_groupgroup C             -0.8558     2.1619  -0.396 0.692355
## ethnic_groupgroup D              2.5663     2.1753   1.180 0.238600
## ethnic_groupgroup E              5.9165     2.3850   2.481 0.013402 *
## parent_educhigh school          -0.5785     1.7584  -0.329 0.742303
## parent_educassociate's degree    4.7948     1.7305   2.771 0.005776 **
## parent_educsome college          2.4082     1.7729   1.358 0.174896
## parent_educbachelor's degree     7.3496     2.0266   3.627 0.000313 ***
## parent_educmaster's degree       8.7149     2.4809   3.513 0.000479 ***
## lunch_typestandard               8.4374     1.1489   7.344 7.31e-13 ***
## test_prepnone                   -6.2822     1.1720  -5.360 1.21e-07 ***
## parent_marital_statusmarried     5.2439     1.5783   3.322 0.000950 ***
## parent_marital_statussingle      1.9235     1.8013   1.068 0.286046
## parent_marital_statuswidowed     5.5863     3.7208   1.501 0.133813
## practice_sportsometimes          0.6757     1.7998   0.375 0.707488
## practice_sportregularly         -0.6843     1.8590  -0.368 0.712923
## is_first_childyes                1.3046     1.1835   1.102 0.270780
## nr_siblings                      0.3882     0.3752   1.035 0.301309
## transport_meansschool_bus        0.2841     1.1351   0.250 0.802472
## wkly_study_hours5-10             2.6835     1.3108   2.047 0.041104 *
## wkly_study_hours> 10             1.0970     1.7121   0.641 0.521971
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 13.2 on 564 degrees of freedom
## Multiple R-squared:  0.2709, Adjusted R-squared:  0.2425
## F-statistic: 9.527 on 22 and 564 DF,  p-value: < 2.2e-16
```

Coefficients and Significance Levels:

- **Intercept (60.8028)**: The expected value of `reading_score` when all other predictors are at their reference level or zero.
- **gendermale (-7.6725, p < 0.001)**: Being male is associated with an average decrease of 7.6725 points in `reading_score` compared to females, holding all else constant. This is statistically significant.
- **ethnic_group**: Only `ethnic_groupgroup E` (5.9165, p = 0.013402) is significant, suggesting students in this group score higher in reading compared to the reference group.
- **parent_educ**: The `associate's degree` (4.7948, p = 0.005776), `bachelor's degree` (7.3496, p = 0.000313), and `master's degree` (8.7149, p = 0.000479) are significant and associated with higher reading scores compared to the reference category.
- **lunch_typestandard (8.4374, p < 0.001)**: Students with standard lunch type score significantly higher.
- **test_prepnone (-6.2822, p < 0.001)**: Not participating in test preparation is associated with lower reading scores.
- **parent_marital_statusmarried (5.2439, p = 0.000950)**: Children of married parents score higher.
- **practice_sport**: Not significant.
- **is_first_childyes**: Not significant.
- **nr_siblings (0.3882, p = 0.301309)**: No significant association with reading scores.
- **transport_meansschool_bus**: Not significant.
- **wkly_study_hours**: Studying 5-10 hours (2.6835, p = 0.041104) shows a significant positive effect.

Residuals:

The spread of residuals suggests the errors are somewhat symmetrically distributed around the predicted values, which is a good sign for linear regression assumptions.

Model Fit:

- **Residual Standard Error (13.2)**: Indicates the average difference between the observed values and the values predicted by the model.

R-squared:

- **Multiple R-squared (0.2709)**: About 27.09% of the variability in `reading_score` is explained by the model.
- **Adjusted R-squared (0.2425)**: Adjusts the R-squared for the number of predictors, a better measure for models with multiple predictors.

Statistic & p-value

- **F-statistic (9.527)** and **p-value (< 2.2e-16)**: The model is statistically significant, meaning it performs better than a model with no predictors.

MLR - writing

```
##
## Call:
## lm(formula = writing_score ~ gender + ethnic_group + parent_educ +
```

```
##     lunch_type + test_prep + parent_marital_status + practice_sport +
##     is_first_child + nr_siblings + transport_means + wkly_study_hours,
##     data = df_transformed)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -46.922  -8.043   1.071   8.811  26.214
##
## Coefficients:
##                                Estimate Std. Error t value Pr(>|t|)
## (Intercept)                   57.808758   3.432409  16.842  < 2e-16 ***
## gendermale                    -9.268845   1.064760  -8.705  < 2e-16 ***
## ethnic_groupgroup B           -1.372239   2.163560  -0.634 0.526175
## ethnic_groupgroup C            0.005008   2.071256   0.002 0.998072
## ethnic_groupgroup D            5.010576   2.084123   2.404 0.016531 *
## ethnic_groupgroup E            6.018419   2.284980   2.634 0.008673 **
## parent_educhigh school        -0.230994   1.684700  -0.137 0.890990
## parent_educassociate's degree  6.130783   1.657904   3.698 0.000239 ***
## parent_educsome college        4.338798   1.698536   2.554 0.010898 *
## parent_educbachelor's degree   9.217680   1.941668   4.747 2.62e-06 ***
## parent_educmaster's degree    11.712279   2.376896   4.928 1.10e-06 ***
## lunch_typestandard             9.390698   1.100772   8.531  < 2e-16 ***
## test_prepnone                 -8.754351   1.122889  -7.796 3.09e-14 ***
## parent_marital_statusmarried   5.246610   1.512157   3.470 0.000561 ***
## parent_marital_statussingle    2.144248   1.725778   1.242 0.214575
## parent_marital_statuswidowed   6.877832   3.564779   1.929 0.054184 .
## practice_sportsometimes        1.674659   1.724312   0.971 0.331863
## practice_sportregularly        1.606102   1.781092   0.902 0.367574
## is_first_childyes              1.045414   1.133850   0.922 0.356921
## nr_siblings                    0.546033   0.359485   1.519 0.129340
## transport_meansschool_bus      0.240107   1.087508   0.221 0.825338
## wkly_study_hours5-10           2.802323   1.255870   2.231 0.026048 *
## wkly_study_hours> 10           1.188892   1.640324   0.725 0.468881
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 12.65 on 564 degrees of freedom
## Multiple R-squared:  0.3634, Adjusted R-squared:  0.3385
## F-statistic: 14.63 on 22 and 564 DF,  p-value: < 2.2e-16
```

Coefficients and Significance Levels:

- **Intercept (57.808758)**: The expected value of `writing_score` when all other predictors are at their reference level or zero.
- **gendermale (-9.268845, $p < 0.001$)**: Being male is associated with an average decrease of 9.268845 points in `writing_score` compared to females, holding all else constant. This is statistically significant.
- **ethnic_group**: `ethnic_groupgroup D` (5.010576, p = 0.016531) and `ethnic_groupgroup E` (6.018419, p = 0.008673) are significant, suggesting students in these groups score higher in writing compared to the reference group.
- **parent_educ**: `associate's degree` (6.130783, p = 0.000239), `some college` (4.338798, p = 0.010898), `bachelor's degree` (9.217680, p = 2.62e-06), and `master's degree` (11.712279, p = 1.10e-06) are significant and associated with higher writing scores compared to the reference category.
- **lunch_typestandard (9.390698, $p < 0.001$)**: Students with standard lunch type score significantly higher.

- **test_prepnone (-8.754351, p < 0.001)**: Not participating in test preparation is associated with lower writing scores.
- **parent_marital_statusmarried (5.246610, p = 0.000561)**: Children of married parents score higher.
- **practice_sport**: Not significant.
- **is_first_childyes**: Not significant.
- **nr_siblings (0.546033, p = 0.129340)**: No significant association with writing scores.
- **transport_meansschool_bus**: Not significant.
- **wkly_study_hours**: Studying 5-10 hours (2.802323, p = 0.026048) shows a significant positive effect.

Residuals:

The spread of residuals suggests the errors are somewhat symmetrically distributed around the predicted values, which is a good sign for linear regression assumptions.

Model Fit:

- **Residual Standard Error (12.65)**: Indicates the average difference between the observed values and the values predicted by the model.

R-squared:

- **Multiple R-squared (0.3634)**: About 36.34% of the variability in `writing_score` is explained by the model.
- **Adjusted R-squared (0.3385)**: Adjusts the R-squared for the number of predictors, a better measure for models with multiple predictors.

Statistic & p-value

- **F-statistic (14.63)** and **p-value (< 2.2e-16)**: The model is statistically significant, meaning it performs better than a model with no predictors.

Cleaned datasets

Step-wise + criteria-based: stepAIC()

Math Score

```
##
## Call:
## lm(formula = math_score ~ gender + ethnic_group + parent_educ +
##     lunch_type + test_prep + nr_siblings + wkly_study_hours,
##     data = math_df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -53.440  -8.894   0.776  10.134  32.889
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)       28.0713     4.2756   6.565 1.15e-10 ***
## gender             5.3017     1.1486   4.616 4.83e-06 ***
## ethnic_group       2.7439     0.4896   5.605 3.23e-08 ***
## parent_educ        1.5210     0.3826   3.976 7.90e-05 ***
## lunch_type        12.5737     1.1964  10.510  < 2e-16 ***
## test_prep         -5.2926     1.1989  -4.414 1.21e-05 ***
```

```
## nr_siblings        0.6927     0.3860   1.795   0.0732 .
## wkly_study_hours   2.0825     0.8723   2.387   0.0173 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 13.8 on 579 degrees of freedom
## Multiple R-squared:  0.2758, Adjusted R-squared:  0.2671
## F-statistic:  31.5 on 7 and 579 DF,  p-value: < 2.2e-16
```

The step-wise-AIC model predicting math score contains gender, ethnic group, parent education level, lunch type, test prep, number of siblings, and weekly study hours.The p-values for gender, ethnic group, parent education level, lunch type, test prep, and weekly study hours were all < 0.05 and are therefore significant. Number of siblings was the only variable whose p-value > 0.05. The overall p-value of the model < 0.05 as well.

Reading Score

```
##
## Call:
## lm(formula = reading_score ~ gender + ethnic_group + parent_educ +
##     lunch_type + test_prep, data = reading_df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -44.354  -8.959   0.802   9.901  32.216
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   66.7121     3.6485  18.285  < 2e-16 ***
## gender        -7.5066     1.1139  -6.739 3.84e-11 ***
## ethnic_group   1.7930     0.4753   3.773 0.000178 ***
## parent_educ    1.7606     0.3713   4.742 2.66e-06 ***
## lunch_type     8.6667     1.1618   7.459 3.18e-13 ***
## test_prep     -6.8289     1.1580  -5.897 6.28e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 13.4 on 581 degrees of freedom
## Multiple R-squared:  0.2264, Adjusted R-squared:  0.2197
## F-statistic: 34.01 on 5 and 581 DF,  p-value: < 2.2e-16
```

The step-wise-AIC model predicting reading score contains gender, ethnic group, parent education level, lunch type, and test prep.The p-values for all of these variables were < 0.05 and are therefore significant. The overall p-value of the model < 0.05 as well.

Writing Score

```
##
## Call:
## lm(formula = writing_score ~ gender + ethnic_group + parent_educ +
##     lunch_type + test_prep + wkly_study_hours, data = writing_df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -49.917  -8.391   0.613   9.143  29.293
##
## Coefficients:
```

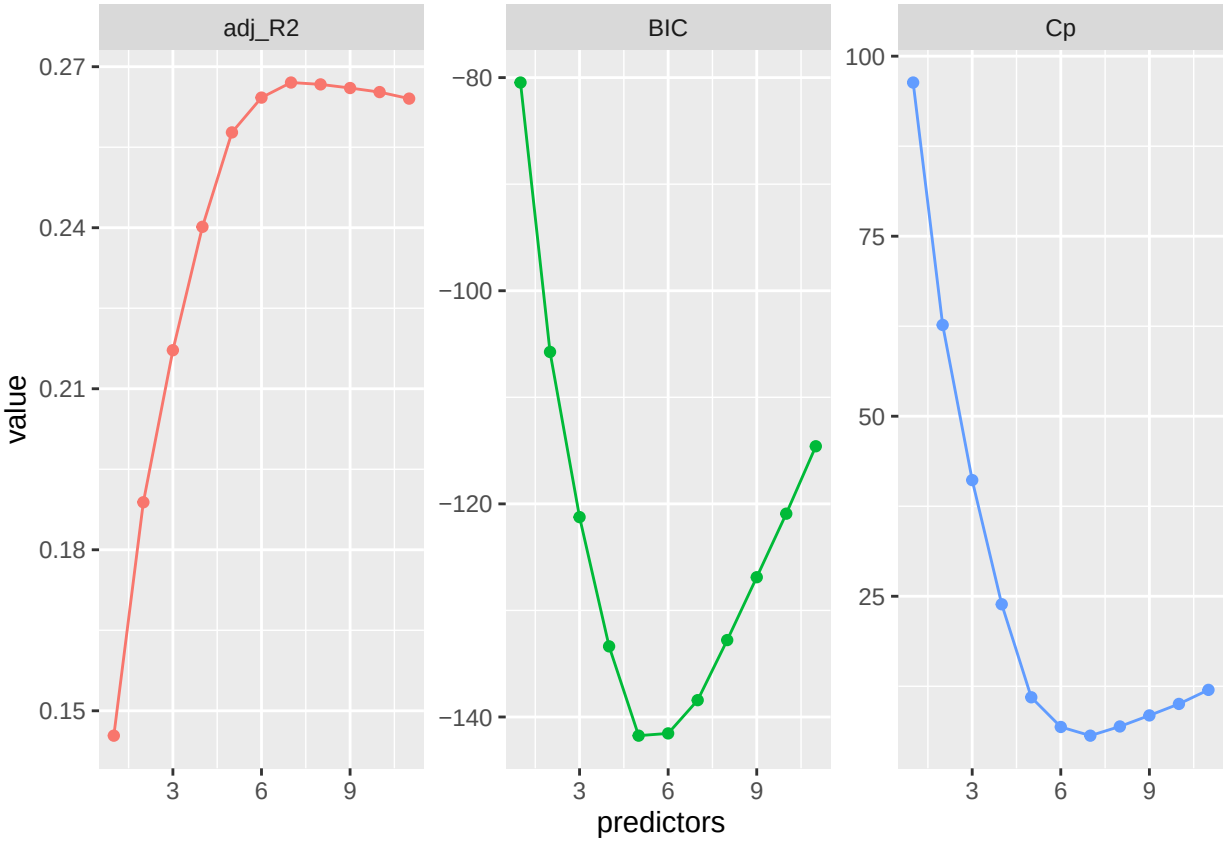
```
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)       65.3125     3.8874  16.801  < 2e-16 ***
## gender            -9.1792     1.0698  -8.581  < 2e-16 ***
## ethnic_group       2.1684     0.4562   4.753 2.53e-06 ***
## parent_educ        2.3242     0.3566   6.519 1.54e-10 ***
## lunch_type         9.4976     1.1151   8.517  < 2e-16 ***
## test_prep         -9.0360     1.1163  -8.094 3.40e-15 ***
## wkly_study_hours   1.1762     0.8121   1.448    0.148
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 12.86 on 580 degrees of freedom
## Multiple R-squared:  0.3233, Adjusted R-squared:  0.3163
## F-statistic: 46.18 on 6 and 580 DF,  p-value: < 2.2e-16
```

The step-wise-AIC model predicting writing score contains gender, ethnic group, parent education level, lunch type, test prep, and weekly study hours.The p-values for gender, ethnic group, parent education level, lunch type, and test prep were all < 0.05 and are therefore significant. Weekly study hours was the only variable whose p-value > 0.05.The overall p-value of the model < 0.05 as well.

The writing score's step-AIC model seemed to have lowest residual standard error out of all three scores' models. It is also interesting to note that the adjusted R^2 values for all three models only differed slightly from their R^2 counterparts by about -0.01 to -0.02.

Criteria-based approach - Adjusted R^2, Cp, and BIC

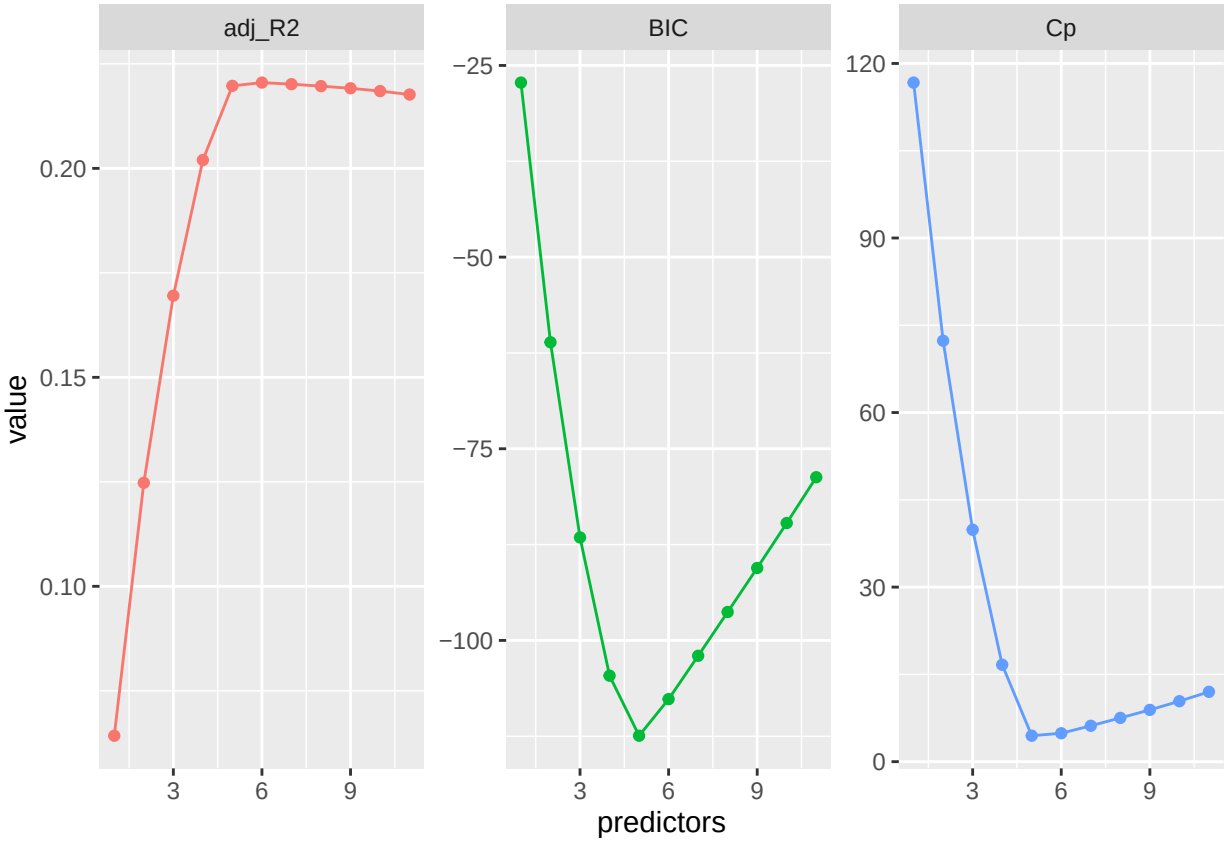
(Note: BIC has a larger penalty, leading to less predictors present within the model.)



Math Score

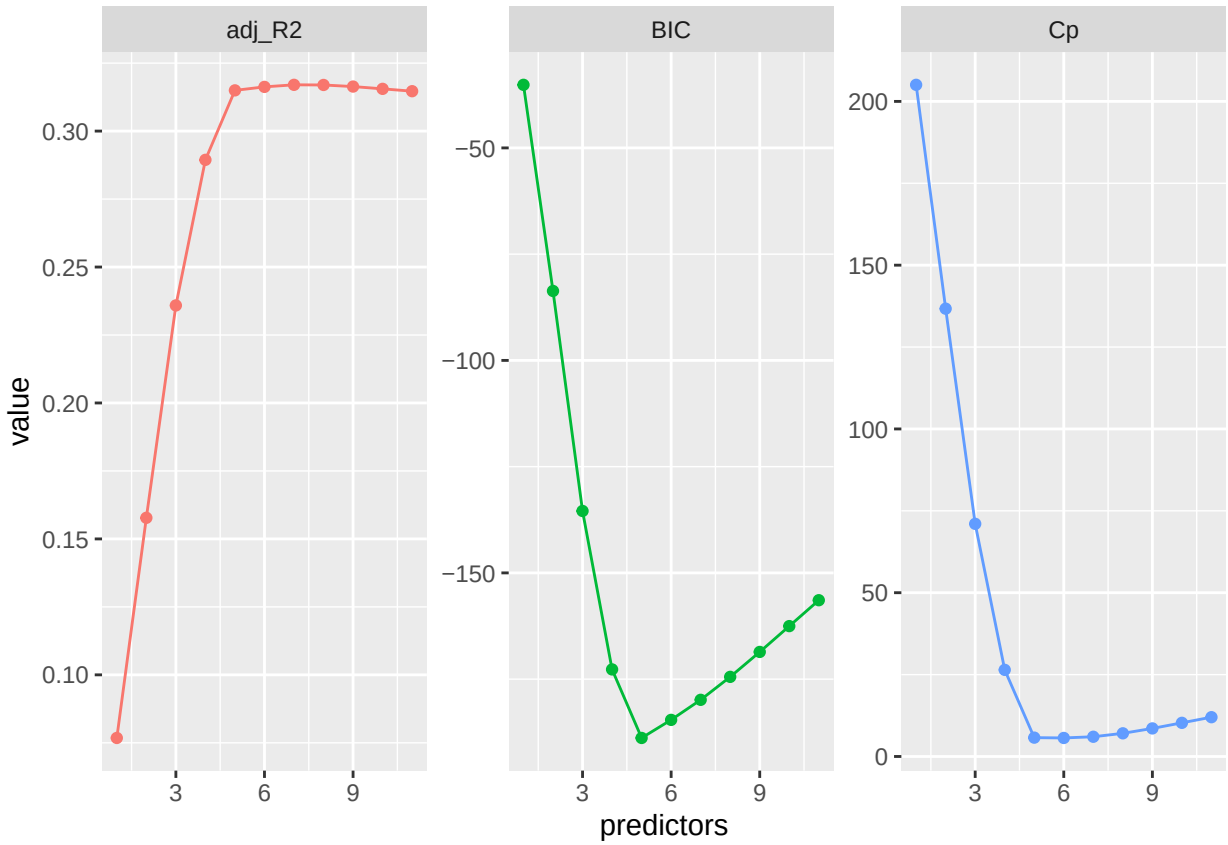
To predict math score, the adjusted R^2 statistic shows that a 7-variable is model is optimal, while the BIC

statistic points to a 5-variable model. The C_p suggests a 7-variable model as well.



Reading Score

To predict reading score, the adjusted R^2 statistic shows that 6 or 7-variable is model is optimal, while the BIC statistic points to a 5-variable model. The C_p seems to suggest a 6 or 7-variable model as well.



Writing Score

To predict writing score, the adjusted R^2 statistic shows that a 7 or 8-variable is model is optimal, while the BIC statistic points to a 5-variable model. The C_p suggests a 7-variable model as well.

LASSO approach -

When lambda = 5, the model will tend to have fewer predictors due to the larger penalty. The number of predictors present in the model will increase as lambda decreases; lambda = 1 tends to have about half of the total predictors (~ 6-7) and lambda = 0.1 typically contains all of the available predictors.

Math score (3):

```
## 12 x 1 sparse Matrix of class "dgCMatrix"
##                              s0
## (Intercept)           62.636459
## gender                 .
## ethnic_group           .
## parent_educ            .
## lunch_type             2.449792
## test_prep              .
## parent_marital_status  .
## practice_sport         .
## is_first_child         .
## nr_siblings            .
## transport_means        .
## wkly_study_hours       .
```

```
## 12 x 1 sparse Matrix of class "dgCMatrix"
##                               s0
## (Intercept)           39.75179929
```

```
## gender                 3.33577736
## ethnic_group           1.98807803
## parent_educ            0.79935701
## lunch_type            10.58669309
## test_prep             -3.47963577
## parent_marital_status  .
## practice_sport         .
## is_first_child         .
## nr_siblings            0.02818102
## transport_means        .
## wkly_study_hours       0.78384148
```

```
## 12 x 1 sparse Matrix of class "dgCMatrix"
##                                s0
## (Intercept)           25.76418765
## gender                 5.12095024
## ethnic_group           2.67800923
## parent_educ            1.45498040
## lunch_type            12.41224863
## test_prep             -5.05068605
## parent_marital_status  0.57160682
## practice_sport         0.47516351
## is_first_child         0.52820267
## nr_siblings            0.62819618
## transport_means        0.04781629
## wkly_study_hours       1.94664266
```

The LASSO model fitted with $\lambda = 5$ reduced all of the predictors' coefficients to zero, except for lunch type which had a coefficient of 2.45. The model fitted with $\lambda = 1$ selected for gender, ethnic group, parent education level, lunch type, test prep, number of siblings, and weekly study hours. The $\lambda = 0.1$ model maintains coefficient values similar in range to those of $\lambda = 1$ model and the corresponding step-wise-AIC model above.

Reading score (3):

```
## 12 x 1 sparse Matrix of class "dgCMatrix"
##                             s0
## (Intercept)           69.84668
## gender                 0.00000
## ethnic_group           .
## parent_educ            .
## lunch_type             .
## test_prep              .
## parent_marital_status  .
## practice_sport         .
## is_first_child         .
## nr_siblings            .
## transport_means        .
## wkly_study_hours       .
```

```
## 12 x 1 sparse Matrix of class "dgCMatrix"
##                              s0
## (Intercept)           67.856478
## gender                -5.413114
## ethnic_group           1.038989
## parent_educ            1.156891
```

```
## lunch_type             6.436282
## test_prep             -4.576598
## parent_marital_status  .
## practice_sport         .
## is_first_child         .
## nr_siblings            .
## transport_means        .
## wkly_study_hours       .
```

```
## 12 x 1 sparse Matrix of class "dgCMatrix"
##                               s0
## (Intercept)           62.6817128
## gender                -7.3115878
## ethnic_group           1.7361352
## parent_educ            1.6939077
## lunch_type             8.4122905
## test_prep             -6.4563567
## parent_marital_status  0.3512184
## practice_sport        -0.5579691
## is_first_child         0.6891704
## nr_siblings            0.2531866
## transport_means        0.6650453
## wkly_study_hours       0.8782682
```

The LASSO model fitted with $\lambda = 5$ reduced all of the predictors' coefficients to zero. The model fitted with $\lambda = 1$ selected for gender, ethnic group, parent education level, lunch type, and test prep. The $\lambda = 0.1$ model maintains coefficient values similar in range to those of $\lambda = 1$ model and the corresponding step-wise-AIC model above.

Writing score (3):

```
## 12 x 1 sparse Matrix of class "dgCMatrix"
##                              s0
## (Intercept)           68.90119
## gender                 0.00000
## ethnic_group           .
## parent_educ            .
## lunch_type             .
## test_prep              .
## parent_marital_status  .
## practice_sport         .
## is_first_child         .
## nr_siblings            .
## transport_means        .
## wkly_study_hours       .
```

```
## 12 x 1 sparse Matrix of class "dgCMatrix"
##                               s0
## (Intercept)           68.901800
## gender                -7.029616
## ethnic_group           1.421530
## parent_educ            1.702391
## lunch_type             7.271135
## test_prep             -6.935167
## parent_marital_status  .
## practice_sport         .
```

```
## is_first_child         .
## nr_siblings            .
## transport_means        .
## wkly_study_hours       .
```

```
## 12 x 1 sparse Matrix of class "dgCMatrix"
##                                s0
## (Intercept)           61.1775776
## gender                -8.9038811
## ethnic_group           2.1242331
## parent_educ            2.2655357
## lunch_type             9.2972877
## test_prep             -8.7621667
## parent_marital_status  0.6208785
## practice_sport         0.3081889
## is_first_child         0.3472107
## nr_siblings            0.3959246
## transport_means        0.5503885
## wkly_study_hours       0.9675351
```

The LASSO model fitted with $\lambda = 5$ reduced all of the predictors' coefficients to zero. The model fitted with $\lambda = 1$ selected for gender, ethnic group, parent education level, lunch type, and test prep. The $\lambda = 0.1$ model maintains coefficient values similar in range to those of $\lambda = 1$ model and the corresponding step-wise-AIC model above.