Logistic Regression Models & Results

Jonathan Olds

11/9/2020

Loading and Prepping Data

```
  batters = read_csv("BattersData.csv")
```

```
## Parsed with column specification:
## cols(
##   .default = col_double(),
##   Name = col_character(),
##   Tm = col_character(),
##   Lg = col_character(),
##   PosSummary_Field = col_character()
## )
```

```
## See spec(...) for full column specifications.
```

```
  pitchers = read_csv("PitchersData.csv")
```

```
## Parsed with column specification:
## cols(
##   .default = col_double(),
##   Name = col_character(),
##   Tm = col_character(),
##   Lg = col_character()
## )
## See spec(...) for full column specifications.
```

```
  # Removing 2008 & 2009 seasons - no list
  batters = batters %>% filter(Season>=2010)
  pitchers = pitchers %>% filter(Season >= 2010)

  # Creating Test & Train data for batters
  set.seed(2020)
  batters$Top100 = as.factor(batters$Top100)
  batters_pi = unique(batters$playerid)
  batters_piselections = batters_pi[createDataPartition(y = batters_pi, p = 0.7, list = FALSE)]
  batters_train = batters[which(batters$playerid %in% batters_piselections),]
  batters_test = batters[which(batters$playerid %!in% batters_piselections),]
  which(batters$Name %in% batters_train & batters$Name %in% batters_test)
```

```
## integer(0)
```

```
  # Create Test & Train data for pitchers
  set.seed(2020)
  pitchers$Top100 = factor(pitchers$Top100)
  pitchers_pi = unique(pitchers$playerid)
```

```r
  pitchers_piselections = pitchers_pi[createDataPartition(y = pitchers_pi, p = 0.7, list = FALSE)]
  pitchers_train = pitchers[which(pitchers$playerid %in% pitchers_piselections),]
  pitchers_test = pitchers[which(pitchers$playerid %!in% pitchers_piselections),]
  which(pitchers$Name %in% pitchers_train & pitchers$Name %in% pitchers_test)
```

```
## integer(0)
```

```r
  # Dataframe of only pca-eligible variables - batters
  batters_active = batters[,c(88:167)]
  batters_active = batters_active[,which(apply(batters_active, 2, sd) != 0)]

  # Dataframe of only pca-eligible variables - pitchers
  pitchers_active = pitchers[,74:140]
  pitchers_active = pitchers_active[,which(apply(pitchers_active, 2, sd) != 0)]

  # Function to calculate test accuracy
  calc_accuracy_function = function(actual, predicted) {
    mean(actual == predicted)
  }
```

Traditional PCA & LR - Batters

Variables Included - Hits, Walks, Strikeouts, Doubles, Triples, Home Runs, Total Bases, Runs Batted In, Batting Average, On Base Percentage, Slugging Percentage, On Base + Slugging, Stolen Bases, Caught Stealing, Runs Created per Game, Putouts, Assists, Errors, Double Plays, Fielding Percentage, Range Factor/9 Innings, All Star, Gold Glove, Silver Slugger, MVP Rank & Vote Points, Rookie of the Year Rank & Vote Points

```r
  # Selecting variables
  batters_traditional = batters_active[,c(4:15,46:47,31,57:62,68:72,75:76)]
  # PCA
  pca_batters_traditional = prcomp(batters_traditional, scale. = TRUE)
  summary(pca_batters_traditional)
```

```
## Importance of components:
##                           PC1    PC2     PC3     PC4     PC5     PC6     PC7
## Standard deviation     2.9388 1.7904 1.62347 1.29731 1.26462 1.21972 1.06107
## Proportion of Variance 0.3085 0.1145 0.09413 0.06011 0.05712 0.05313 0.04021
## Cumulative Proportion  0.3085 0.4229 0.51706 0.57717 0.63428 0.68742 0.72763
##                           PC8     PC9    PC10    PC11    PC12    PC13    PC14
## Standard deviation     1.00601 0.96358 0.92043 0.86406 0.82590 0.80536 0.76788
## Proportion of Variance 0.03615 0.03316 0.03026 0.02666 0.02436 0.02316 0.02106
## Cumulative Proportion  0.76377 0.79693 0.82719 0.85385 0.87821 0.90138 0.92244
##                           PC15    PC16    PC17    PC18    PC19    PC20    PC21
## Standard deviation     0.67243 0.65646 0.59478 0.48479 0.40753 0.38659 0.35311
## Proportion of Variance 0.01615 0.01539 0.01263 0.00839 0.00593 0.00534 0.00445
## Cumulative Proportion  0.93859 0.95398 0.96661 0.97500 0.98094 0.98627 0.99073
##                           PC22    PC23    PC24    PC25    PC26     PC27
## Standard deviation     0.32744 0.24389 0.21275 0.17091 0.13589 0.005121
## Proportion of Variance 0.00383 0.00212 0.00162 0.00104 0.00066 0.000000
## Cumulative Proportion  0.99456 0.99668 0.99830 0.99934 1.00000 1.000000
##                           PC28
## Standard deviation     1.414e-05
## Proportion of Variance 0.000e+00
## Cumulative Proportion  1.000e+00
```

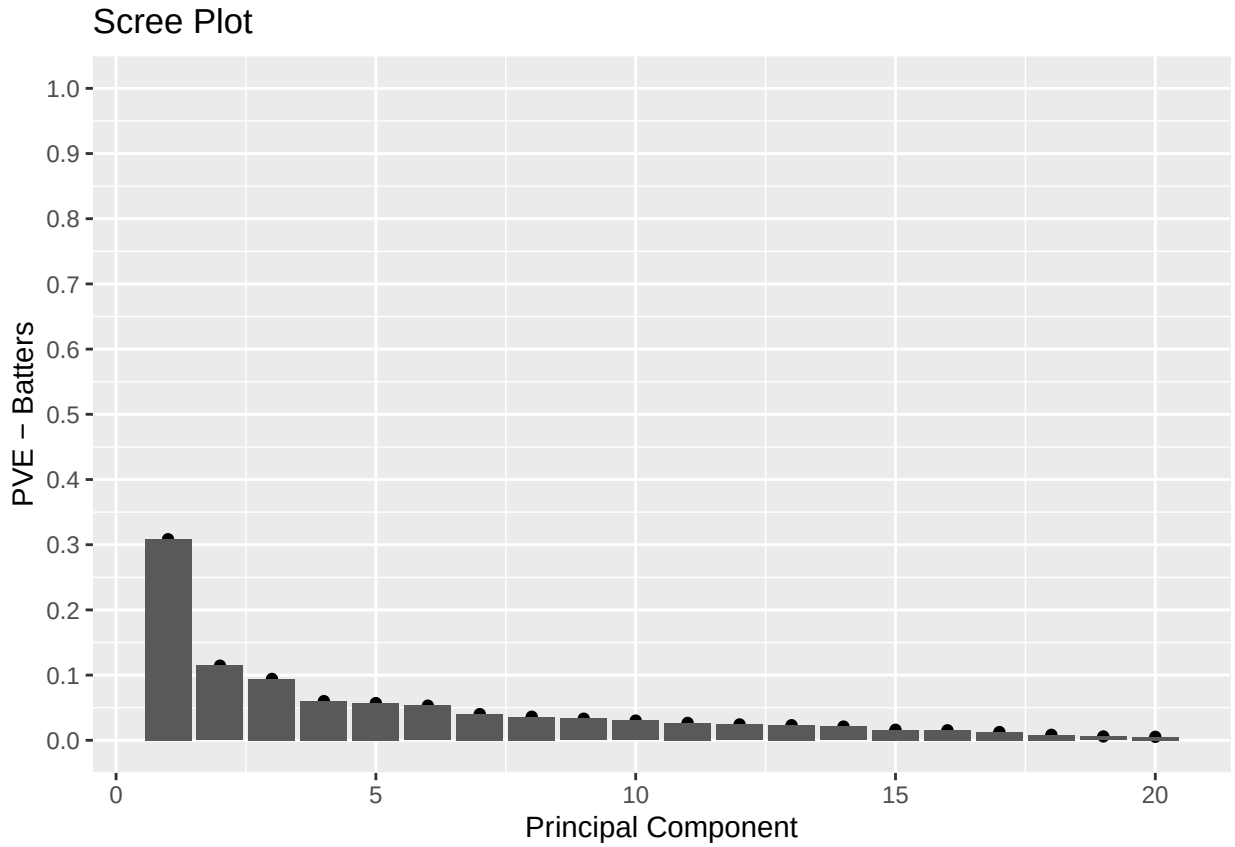
```r
cbind(batters[1:6,1],pca_batters_traditional$x[1:6,1:6])
```

```
##              Name        PC1      PC2         PC3       PC4        PC5
## 1      A.J. Ellis -1.7817308 2.250087 -0.67723277 -1.253646 -1.2095306
## 2      A.J. Ellis -2.1023261 2.633659  0.38138262 -1.357371  0.2617816
## 3      A.J. Ellis -3.4135491 2.817530 -0.06135366 -1.577257 -0.2328134
## 4 A.J. Pierzynski -0.4035745 1.433503  0.62050661 -1.218516 -0.6651692
## 5 A.J. Pierzynski -0.7206019 1.437979  0.37298023 -1.464506 -1.0104501
## 6 A.J. Pierzynski -0.1896964 1.632686  0.27890080 -1.097944 -0.6942622
##         PC6
## 1 0.8593889
## 2 1.2425418
## 3 0.9081588
## 4 0.6067756
## 5 0.5233870
## 6 0.6924411
```

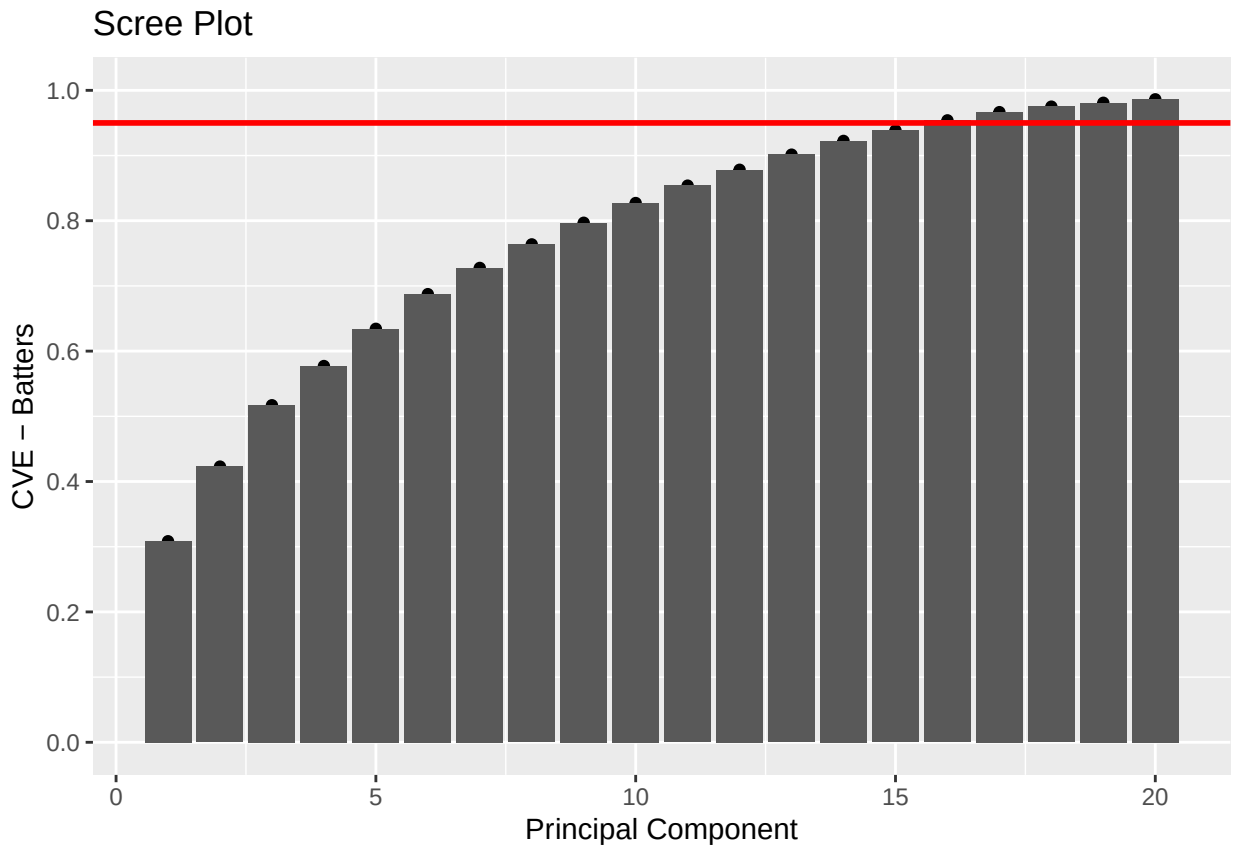
```r
head(pca_batters_traditional$scale^2, n = 6)
```

```
##   H_Bat_3yravg  BB_Bat_3yravg  SO_Bat_3yravg Doubles_3yravg Triples_3yravg
##    1111.443108     333.499422     918.949093      56.514469       3.732683
##  HR_Bat_3yravg
##      68.971448
```

```r
# Assigning two elements of variability to vectors
PVE = summary(pca_batters_traditional)$importance[2,]
CVE = summary(pca_batters_traditional)$importance[3,]

# Graph of variability explained
PVEplot <- qplot(c(1:20), PVE[1:20]) +
  geom_bar(stat = "Identity") +
  xlab("Principal Component") +
  ylab("PVE - Batters") +
  ggtitle("Scree Plot") +
  scale_y_continuous(limits = c(0,1), breaks = seq(0,1,0.1))
PVEplot
```




```
# Flattens out after the 17th PCA component

#Graph of cumulative variance explained
CVEplot <- qplot(c(1:20), CVE[1:20]) +
  geom_bar(stat = "Identity") +
  xlab("Principal Component") +
  ylab("CVE - Batters") +
  ggtitle("Scree Plot") +
  scale_y_continuous(limits = c(0,1), breaks = seq(0,1,0.2)) +
  geom_hline(yintercept = 0.95, color = "red", lwd = 1)
CVEplot
```




```
  # Reaches 95% cumulative variability after 16th component

  # Adding pca components and descriptive values to dataset
  batters_traditional = cbind(batters_traditional, pca_batters_traditional$x[,1:16])
  batters_traditional = cbind(batters[,c(1:6,190:193)], batters_traditional)

  # Dividing into test and train
  batters_train = batters_traditional[which(batters_traditional$playerid %in% batters_piselections),]
  batters_test = batters_traditional[which(batters_traditional$playerid %!in% batters_piselections),]

  # Logistic regression model
  set.seed(2020)
  batters_glm_traditional = train(
    form = Top100 ~ PC1 + PC2 + PC3 + PC4 + PC5 + PC6 + PC7 + PC8 + PC9 + PC10 + PC11 +
      PC12 + PC13 + PC14 + PC15 + PC16,
    data = batters_train,
    trControl = trainControl(method = "cv", number = 10),
    method = "glm",
    family = "binomial"
  )

  # Model summary
  batters_glm_traditional
```

```
## Generalized Linear Model
##
```

```
## 2075 samples
##   16 predictor
##    2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 1868, 1868, 1867, 1868, 1867, 1867, ...
## Resampling results:
##
##   Accuracy   Kappa
##   0.8751503  0.6284962
```

```
  # Model values
  batters_glm_traditional$finalModel
```

```
##
## Call:  NULL
##
## Coefficients:
## (Intercept)          PC1          PC2          PC3          PC4          PC5
##   -1.820592     0.871360    -0.134018    -0.178487    -0.046128    -0.306205
##         PC6          PC7          PC8          PC9         PC10         PC11
##   -0.075178    -0.263394     0.514182     0.162792    -0.421786     0.067456
##        PC12         PC13         PC14         PC15         PC16
##   -0.093055     0.007351     0.459836    -0.253259     0.045947
##
## Degrees of Freedom: 2074 Total (i.e. Null);  2058 Residual
## Null Deviance:       2285
## Residual Deviance: 1229  AIC: 1263
```

```
  # Test data accuracy
  calc_accuracy_function(batters_test$Top100,
                         predict(batters_glm_traditional, newdata = batters_test))
```

```
## [1] 0.8792711
```

```
  # Dataset of predictions v actual
  batterscomp_traditional = cbind(batters_train$Name, predict(batters_glm_traditional,
                                                              newdata = batters_train,
                                                              type = "prob"), batters_train$Top100)
  head(batterscomp_traditional)
```

```
##   batters_train$Name         0           1 batters_train$Top100
## 1         A.J. Ellis 0.9711324 0.028867608                    0
## 2         A.J. Ellis 0.9894933 0.010506690                    0
## 3         A.J. Ellis 0.9935247 0.006475291                    0
## 4    A.J. Pierzynski 0.9558149 0.044185071                    0
## 5    A.J. Pierzynski 0.9624850 0.037515043                    0
## 6    A.J. Pierzynski 0.9403715 0.059628537                    1
```

```
  # Confusion matrix
  batters_cm_trad = confusionMatrix(predict(batters_glm_traditional,newdata = batters_test), batters_te
  batters_cm_trad$table
```

```
##           Reference
## Prediction   0   1
##          0 654  81
```

```
##          1  25 118
```

Traditional PCA & LR - Pitchers

Variables Included - Wins, Losses, Complete Games, Shutouts, Saves, Hits, Runs, Earned Runs, Earned Run Average, Walks + Hits/Innings Pitched, Run Support Per 9, Home Runs Per 9, Walks Per 9, Strikeouts Per 9, Runs Against Per 9, All Star, Gold Glove, Silver Slugger, MVP Rank and Vote Points, Cy Young Rank and Vote Points, Rookie of the Year Rank and Vote Points

```
# Selecting variables
pitchers_traditional = pitchers_active[,c(1:2,5:7,13:18,20:23,50:54,57:58,61:62)]
# PCA
pca_pitchers_traditional = prcomp(pitchers_traditional, scale. = TRUE)
summary(pca_pitchers_traditional)
```

```
## Importance of components:
##                           PC1    PC2    PC3     PC4     PC5     PC6     PC7
## Standard deviation     2.4743 2.0615 1.3744 1.18180 1.13564 1.09429 0.98493
## Proportion of Variance 0.2551 0.1771 0.0787 0.05819 0.05374 0.04989 0.04042
## Cumulative Proportion  0.2551 0.4322 0.5109 0.56907 0.62280 0.67270 0.71312
##                           PC8     PC9    PC10    PC11    PC12    PC13    PC14
## Standard deviation     0.98323 0.93767 0.89762 0.85965 0.81155 0.78867 0.74267
## Proportion of Variance 0.04028 0.03663 0.03357 0.03079 0.02744 0.02592 0.02298
## Cumulative Proportion  0.75340 0.79003 0.82360 0.85440 0.88184 0.90775 0.93074
##                           PC15    PC16    PC17    PC18    PC19    PC20    PC21
## Standard deviation     0.66339 0.60247 0.57686 0.41680 0.36798 0.32320 0.27975
## Proportion of Variance 0.01834 0.01512 0.01387 0.00724 0.00564 0.00435 0.00326
## Cumulative Proportion  0.94907 0.96420 0.97806 0.98530 0.99094 0.99529 0.99856
##                           PC22    PC23    PC24
## Standard deviation     0.14572 0.10866 0.04022
## Proportion of Variance 0.00088 0.00049 0.00007
## Cumulative Proportion  0.99944 0.99993 1.00000
```

```
cbind(pitchers[1:6,1],pca_pitchers_traditional$x[1:6,1:6])
```

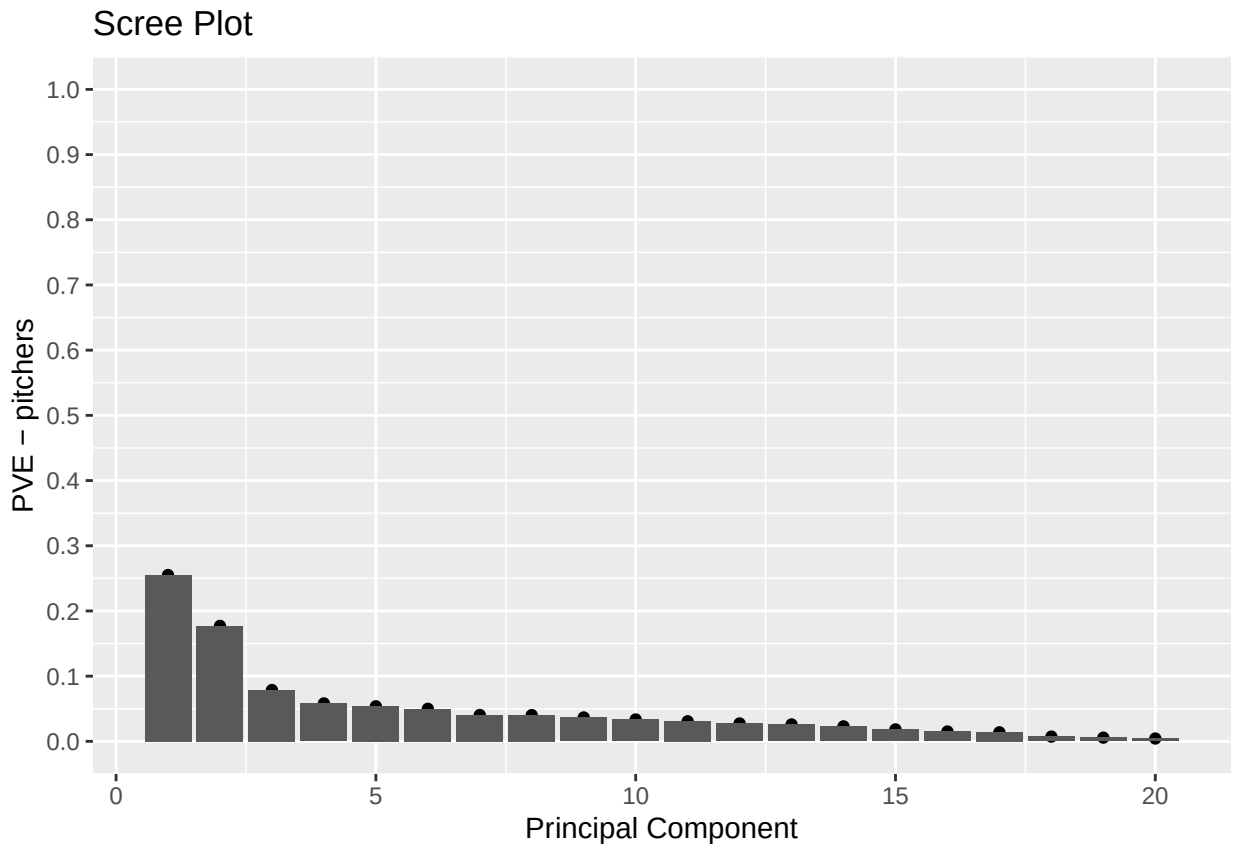
```
##           Name       PC1        PC2       PC3        PC4         PC5        PC6
## 1 A.J. Burnett -4.292265 -1.6865132 -1.304909 -1.3708570 -0.01060507 -0.4932591
## 2 A.J. Burnett -3.986755 -2.3172783 -1.185097 -1.4124966 -0.09406051 -0.5868490
## 3 A.J. Burnett -4.303699 -1.7869879 -1.263816 -1.2252483  0.15905185 -0.5520055
## 4 A.J. Burnett -3.607454 -0.6621535 -1.354841 -0.9805361  0.20482561 -0.4475592
## 5 A.J. Burnett -3.935994 -0.4447429 -1.457616 -1.2737249  0.34575563 -0.5661478
## 6 A.J. Burnett -3.028110 -0.2458442 -1.184939 -1.4300465  0.05722687 -0.8335369
```

```
head(pca_pitchers_traditional$scale^2, n = 6)
```

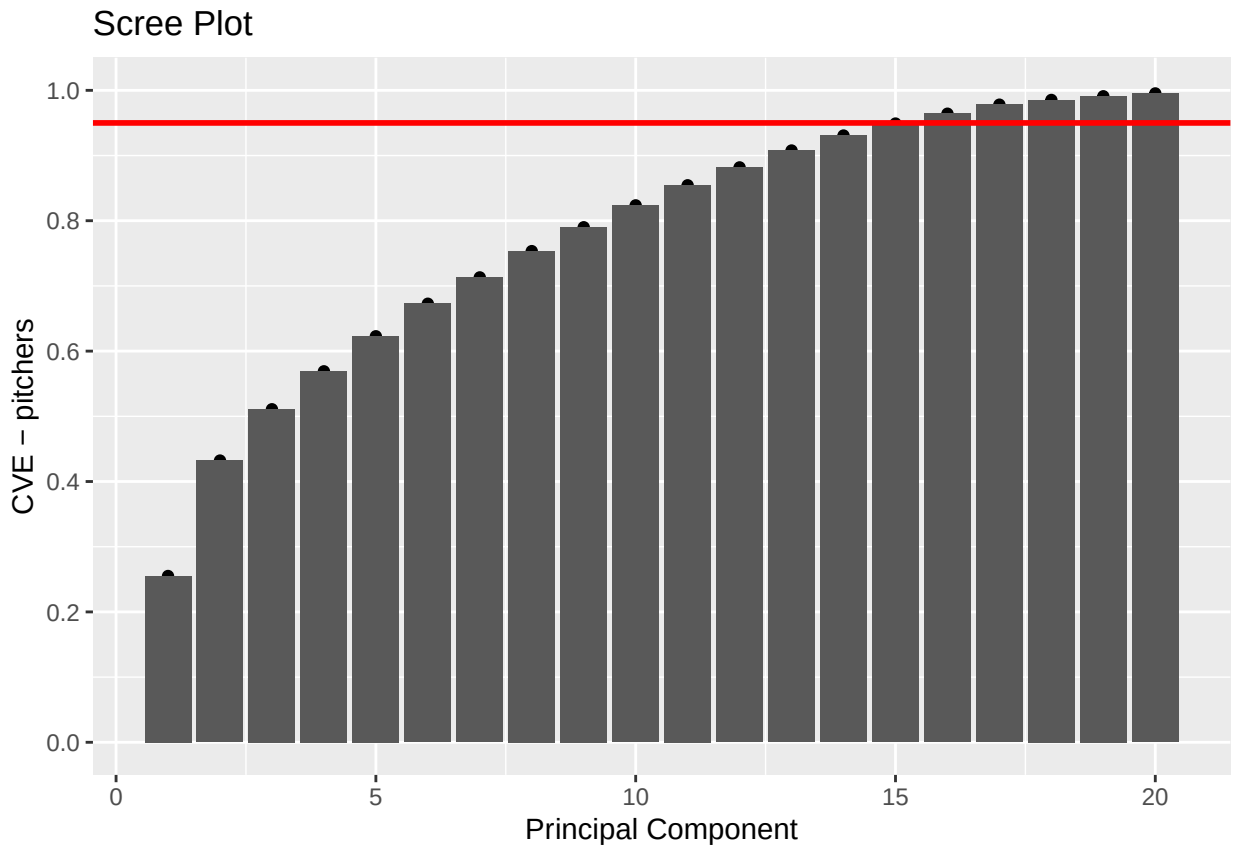
```
##       W_3yravg       L_3yravg      CG_3yravg     SHO_3yravg      SV_3yravg
##   1.371911e+01   8.998276e+00   4.124620e-01   9.723845e-02   5.121191e+01
## H_Pitch_3yravg
##   2.439816e+03
```

```
# Assigning elements of variability to vectors
PVE = summary(pca_pitchers_traditional)$importance[2,]
CVE = summary(pca_pitchers_traditional)$importance[3,]

# Graph of variability explained
PVEplot <- qplot(c(1:20), PVE[1:20]) +
  geom_bar(stat = "Identity") +
```

```
  xlab("Principal Component") +
  ylab("PVE - pitchers") +
  ggtitle("Scree Plot") +
  scale_y_continuous(limits = c(0,1), breaks = seq(0,1,0.1))
PVEplot
```




```
# Flattens out after the 17th PCA component

# Graph of cumulative variance explained
CVEplot <- qplot(c(1:20), CVE[1:20]) +
  geom_bar(stat = "Identity") +
  xlab("Principal Component") +
  ylab("CVE - pitchers") +
  ggtitle("Scree Plot") +
  scale_y_continuous(limits = c(0,1), breaks = seq(0,1,0.2)) +
  geom_hline(yintercept = 0.95, color = "red", lwd = 1)
CVEplot
```




```
  # Reaches 95% cumulative variability after 16th component

  # Adding PCA components and descriptive statistics to dataset
  pitchers_traditional = cbind(pitchers_traditional, pca_pitchers_traditional$x[,1:16])
  pitchers_traditional = cbind(pitchers[,c(1:6,163:166)], pitchers_traditional)

  # Dividing into test and train
  pitchers_train = pitchers_traditional[which(pitchers_traditional$playerid %in% pitchers_piselections)
  pitchers_test = pitchers_traditional[which(pitchers_traditional$playerid %!in% pitchers_piselections)

  # Logistic Regression Model
  set.seed(2020)
  pitchers_glm_traditional = train(
    form = Top100 ~ PC1 + PC2,
    data = pitchers_train,
    trControl = trainControl(method = "cv", number = 10),
    method = "glm",
    family = "binomial"
  )

  # Model summary
  pitchers_glm_traditional
```

```
## Generalized Linear Model
##
## 2789 samples
```

```
##    2 predictor
##    2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 2510, 2510, 2510, 2510, 2510, 2510, ...
## Resampling results:
##
##   Accuracy   Kappa
##   0.9598424  0.6196805
```

```
  # Model values
  pitchers_glm_traditional$finalModel
```

```
##
## Call:  NULL
##
## Coefficients:
## (Intercept)          PC1          PC2
##      -4.640       -0.500        1.278
##
## Degrees of Freedom: 2788 Total (i.e. Null);  2786 Residual
## Null Deviance:       1382
## Residual Deviance: 624.7     AIC: 630.7
```

```
  # Test accuracy
  calc_accuracy_function(pitchers_test$Top100,
                         predict(pitchers_glm_traditional, newdata = pitchers_test))
```

```
## [1] 0.9498767
```

```
  # Dataset measuring predictions vs accuracy
  pitcherscomp_traditional = cbind(pitchers_train$Name, predict(pitchers_glm_traditional,
                                                    newdata = pitchers_train,
                                                    type = "prob"), pitchers_train$Top100)
  head(pitcherscomp_traditional)
```

```
##   pitchers_train$Name         0           1 pitchers_train$Top100
## 1        A.J. Burnett 0.9905195 0.009480454                     0
## 2        A.J. Burnett 0.9963435 0.003656476                     0
## 3        A.J. Burnett 0.9916046 0.008395372                     0
## 4        A.J. Burnett 0.9754622 0.024537811                     0
## 5        A.J. Burnett 0.9623366 0.037663379                     0
## 6        A.J. Burnett 0.9689463 0.031053709                     0
```

```
  # Confusion Matrix
  pitchers_cm_trad = confusionMatrix(predict(pitchers_glm_traditional, newdata = pitchers_test),pitchers
  pitchers_cm_trad$table
```

```
##            Reference
## Prediction    0    1
##          0 1087   46
##          1   15   69
```

Advanced PCA & LR - Batters

Variables Included - Batting Average on Balls in Play, Line Drive Percentage, Ground Ball Percentage, Fly Ball Percentage, Home Runs per Fly Ball, Pull Percent, Center Percent, Opposite Field Percent, Soft Contact Percent, Medium Contact Percent, Hard Contact Percent, Walks per Strikeout, weighted On Base Average, On Base Plus Slugging Plus, weighted Runs Created Plus, Batting Wins (BR), Wins Above Average, WAR (BR), oWAR (BR), WAR (FG), Runs Expectancy Wins, Win Probability Added, Player Leverage Index, Win Probability Added Per Leverage, Clutch, Offensive Winning Percentage, Batting Wins (FG), oWAR (FG), Ultimate Base Running, weighted Grounded into Double Plays, weighted Stolen Bases, Base Running Runs, Defensive Runs Saved (BR), Runs Saved on Good Plays, dWAR (BR), DRS (FG), dWAR (FG), All Star, Gold Glove, Silver Slugger, MVP Rank & Voting Points, Rookie of the Year Rank & Voting Points

```
# Selecting Variables
batters_advanced = batters_active[,c(16:29,32:45,48:51,63:72,75:76)]
# PCA
pca_batters_advanced = prcomp(batters_advanced, scale. = TRUE)
summary(pca_batters_advanced)
```

```
## Importance of components:
##                           PC1    PC2     PC3     PC4     PC5    PC6     PC7
## Standard deviation     3.6229 2.3010 1.90395 1.62592 1.30766 1.2356 1.18013
## Proportion of Variance 0.2983 0.1203 0.08239 0.06008 0.03886 0.0347 0.03165
## Cumulative Proportion  0.2983 0.4186 0.50102 0.56110 0.59996 0.6347 0.66631
##                           PC8     PC9    PC10    PC11    PC12    PC13    PC14
## Standard deviation     1.12971 1.06371 1.01225 0.98767 0.97367 0.94487 0.90239
## Proportion of Variance 0.02901 0.02572 0.02329 0.02217 0.02155 0.02029 0.01851
## Cumulative Proportion  0.69532 0.72103 0.74432 0.76649 0.78804 0.80833 0.82683
##                           PC15    PC16    PC17    PC18    PC19    PC20    PC21
## Standard deviation     0.88157 0.85104 0.82331 0.80363 0.78623 0.74636 0.73071
## Proportion of Variance 0.01766 0.01646 0.01541 0.01468 0.01405 0.01266 0.01214
## Cumulative Proportion  0.84450 0.86096 0.87636 0.89104 0.90509 0.91775 0.92988
##                           PC22    PC23    PC24    PC25    PC26    PC27   PC28
## Standard deviation     0.70874 0.66353 0.65521 0.61988 0.60918 0.53185 0.4297
## Proportion of Variance 0.01142 0.01001 0.00976 0.00873 0.00843 0.00643 0.0042
## Cumulative Proportion  0.94130 0.95131 0.96106 0.96980 0.97823 0.98466 0.9889
##                           PC29    PC30    PC31    PC32    PC33    PC34    PC35
## Standard deviation     0.35842 0.33353 0.29418 0.24480 0.20504 0.15913 0.12652
## Proportion of Variance 0.00292 0.00253 0.00197 0.00136 0.00096 0.00058 0.00036
## Cumulative Proportion  0.99178 0.99430 0.99627 0.99763 0.99859 0.99916 0.99953
##                           PC36    PC37    PC38    PC39    PC40    PC41    PC42
## Standard deviation     0.09220 0.08320 0.04465 0.03993 0.03104 0.02377 0.01565
## Proportion of Variance 0.00019 0.00016 0.00005 0.00004 0.00002 0.00001 0.00001
## Cumulative Proportion  0.99972 0.99988 0.99992 0.99996 0.99998 0.99999 1.00000
##                           PC43     PC44
## Standard deviation     0.003612 0.001772
## Proportion of Variance 0.000000 0.000000
## Cumulative Proportion  1.000000 1.000000
```

```
cbind(batters[1:6,1],pca_batters_advanced$x[1:6,1:6])
```

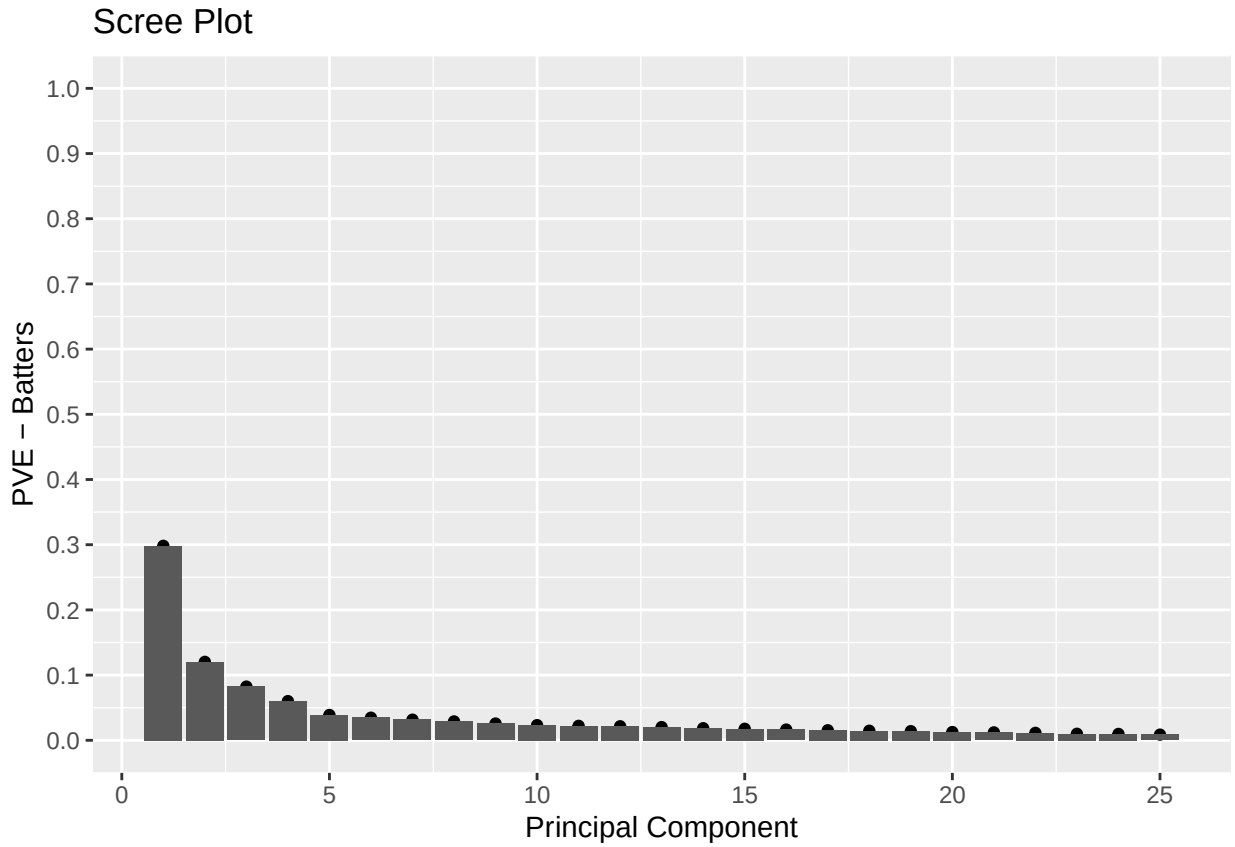
```
##              Name       PC1        PC2        PC3       PC4          PC5
## 1      A.J. Ellis 0.2062065 -0.1002327 -1.4889009 0.4853071  0.343873751
## 2      A.J. Ellis 1.8376461 -0.4808878 -1.6188972 1.8248646 -0.190853413
## 3      A.J. Ellis 2.2421148 -0.9227380 -1.0371102 1.6539492 -0.826363864
## 4 A.J. Pierzynski 3.6595899 -1.0111134 -0.6137027 1.4369921  0.367040748
## 5 A.J. Pierzynski 3.4761050 -0.3749331 -1.0914236 1.8576937 -0.023311120
```

```
## 6 A.J. Pierzynski 2.1192048 -0.8670503 -0.6787158 1.2259140 -0.001398269
##           PC6
## 1 -0.61895130
## 2 -0.30155604
## 3  0.01638817
## 4 -0.41074673
## 5 -0.34912123
## 6 -0.33819364
```

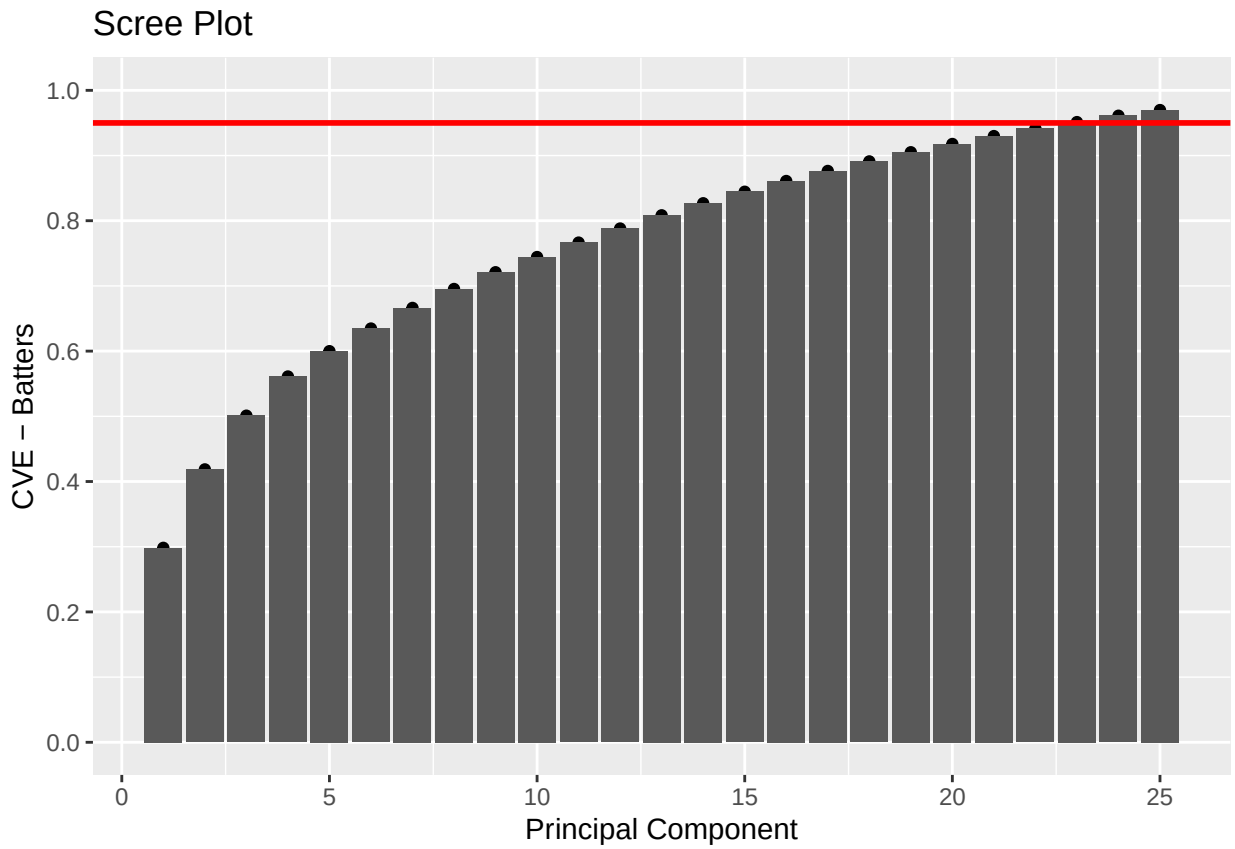
```
head(pca_batters_advanced$scale^2, n = 6)
```

```
##           BAbip_3yravg   LDPercent_Bat_3yravg   GBPercent_Bat_3yravg
##             0.00114843             7.30450385            41.57701196
##   FBPercent_Bat_3yravg         HRPerFB_3yravg PullPercent_Bat_3yravg
##            43.84569385            31.89357589            31.84198988
```

```
# Assigning elements of variability to vectors
PVE = summary(pca_batters_advanced)$importance[2,]
CVE = summary(pca_batters_advanced)$importance[3,]

# Graph of variability explained
PVEplot <- qplot(c(1:25), PVE[1:25]) +
  geom_bar(stat = "Identity") +
  xlab("Principal Component") +
  ylab("PVE - Batters") +
  ggtitle("Scree Plot") +
  scale_y_continuous(limits = c(0,1), breaks = seq(0,1,0.1))
PVEplot
```




```
# Flattens out after the 18th PCA component

# Graph of cumulative variability explained
CVEplot <- qplot(c(1:25), CVE[1:25]) +
  geom_bar(stat = "Identity") +
  xlab("Principal Component") +
  ylab("CVE - Batters") +
  ggtitle("Scree Plot") +
  scale_y_continuous(limits = c(0,1), breaks = seq(0,1,0.2)) +
  geom_hline(yintercept = 0.95, color = "red", lwd = 1)
CVEplot
```




```
  # Reaches 95% cumulative variability after 23rd component

  # Adding PCA components and descriptive statistics back to dataset
  batters_advanced = cbind(batters_advanced, pca_batters_advanced$x[,1:23])
  batters_advanced = cbind(batters[,c(1:6,190:193)], batters_advanced)

  # Dividing into test and train
  batters_train = batters_advanced[which(batters_advanced$playerid %in% batters_piselections),]
  batters_test = batters_advanced[which(batters_advanced$playerid %!in% batters_piselections),]

  # Logistic regression model
  set.seed(2020)
  batters_glm_advanced = train(
    form = Top100 ~ PC1 + PC2 + PC3 + PC4 + PC5 + PC6 + PC7 + PC8 + PC9 + PC10 +
      PC11 + PC12 + PC13 + PC14,
    data = batters_train,
    trControl = trainControl(method = "cv", number = 10),
    method = "glm",
    family = "binomial"
  )

  # Model summary
  batters_glm_advanced
```

```
## Generalized Linear Model
##
```

```
## 2075 samples
##   14 predictor
##    2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 1868, 1868, 1867, 1868, 1867, 1867, ...
## Resampling results:
##
##   Accuracy   Kappa
##   0.8954124  0.6967778
```

```
  # Model values
  batters_glm_advanced$finalModel
```

```
##
## Call:  NULL
##
## Coefficients:
## (Intercept)          PC1          PC2          PC3          PC4          PC5
##    -2.19094     -0.91008      0.31294      0.12142     -0.01471      0.10522
##         PC6          PC7          PC8          PC9         PC10         PC11
##     0.47299     -0.32217      0.28606     -0.17598      0.06734     -0.07803
##        PC12         PC13         PC14
##     0.03779      0.15950     -0.27304
##
## Degrees of Freedom: 2074 Total (i.e. Null);  2060 Residual
## Null Deviance:       2285
## Residual Deviance: 966.1     AIC: 996.1
```

```
  # Test accuracy
  calc_accuracy_function(batters_test$Top100,
                         predict(batters_glm_advanced, newdata = batters_test))
```

```
## [1] 0.88041
```

```
  # Dataset measuring predictions vs accuracy
  batterscomp_advanced = cbind(batters_train$Name, predict(batters_glm_advanced,
                                                           newdata = batters_train,
                                                           type = "prob"), batters_train$Top100)
  head(batterscomp_advanced)
```

```
##   batters_train$Name         0           1 batters_train$Top100
## 1         A.J. Ellis 0.8998968 0.100103187                    0
## 2         A.J. Ellis 0.9759615 0.024038482                    0
## 3         A.J. Ellis 0.9849687 0.015031260                    0
## 4    A.J. Pierzynski 0.9903079 0.009692068                    0
## 5    A.J. Pierzynski 0.9868904 0.013109571                    0
## 6    A.J. Pierzynski 0.9702758 0.029724209                    1
```

```
  # Confusion Matrix
  batters_cm_adv = confusionMatrix(predict(batters_glm_advanced, newdata = batters_test),batters_test$T
  batters_cm_adv$table
```

```
##           Reference
## Prediction   0   1
##          0 638  64
```

```
##          1  41 135
```

Advanced PCA & LR - Pitchers

Variables Included - Left on Base Percentage, Line Drive Percentage, Fly Ball Percentage, Ground Ball Percentage, Soft Contact Percentage, Medium Contact Percentage, Hard Contact Percentage, Batting Average on Balls in Play, Earned Run Average Plus, Fielding Independent Pitching, Expected Fielding Independent Pitching, Skill Interactive Earned Run Average, WAR (FG), game Leverage, Wins Above Average, Wins Above Average adjusted, Wins Above Average Win-Loss %, Full Season Win-Loss Percent, WAR (BR), Win Probability Added, Runs Expectancy Wins, player Leverage Index, Win Probability Added per Leverage, Clutch, Shutdowns, Meltdowns, All Star, Gold Glove, Silver Slugger, MVP Rank & Vote Points, Cy Young Rank & Vote Points, Rookie of the Year Rank & Vote Points

```r
# Selecting variables
pitchers_advanced = pitchers_active[,c(24:49,50:54,57:58,61:62)]
# PCA
pca_pitchers_advanced = prcomp(pitchers_advanced, scale. = TRUE)
summary(pca_pitchers_advanced)
```

```
## Importance of components:
##                           PC1   PC2     PC3     PC4     PC5     PC6     PC7
## Standard deviation     2.999 2.117 1.54217 1.28241 1.25847 1.20316 1.14822
## Proportion of Variance 0.257 0.128 0.06795 0.04699 0.04525 0.04136 0.03767
## Cumulative Proportion  0.257 0.385 0.45296 0.49994 0.54519 0.58655 0.62422
##                           PC8     PC9   PC10    PC11    PC12    PC13    PC14
## Standard deviation     1.10615 1.08014 1.0399 1.00804 0.98038 0.95609 0.93521
## Proportion of Variance 0.03496 0.03333 0.0309 0.02903 0.02746 0.02612 0.02499
## Cumulative Proportion  0.65918 0.69252 0.7234 0.75245 0.77991 0.80603 0.83101
##                           PC15    PC16    PC17    PC18    PC19    PC20    PC21
## Standard deviation     0.87629 0.86084 0.80349 0.79440 0.75871 0.72141 0.63302
## Proportion of Variance 0.02194 0.02117 0.01845 0.01803 0.01645 0.01487 0.01145
## Cumulative Proportion  0.85295 0.87413 0.89257 0.91060 0.92705 0.94192 0.95337
##                           PC22   PC23   PC24    PC25    PC26    PC27    PC28
## Standard deviation     0.58637 0.5551 0.5122 0.42935 0.39756 0.37545 0.29918
## Proportion of Variance 0.00982 0.0088 0.0075 0.00527 0.00452 0.00403 0.00256
## Cumulative Proportion  0.96319 0.9720 0.9795 0.98476 0.98928 0.99330 0.99586
##                           PC29    PC30    PC31   PC32    PC33    PC34    PC35
## Standard deviation     0.2136 0.18124 0.17342 0.1180 0.10599 0.09061 0.05463
## Proportion of Variance 0.0013 0.00094 0.00086 0.0004 0.00032 0.00023 0.00009
## Cumulative Proportion  0.9972 0.99810 0.99896 0.9994 0.99968 0.99991 1.00000
```

```r
cbind(pitchers[1:6,1],pca_pitchers_advanced$x[1:6,1:6])
```

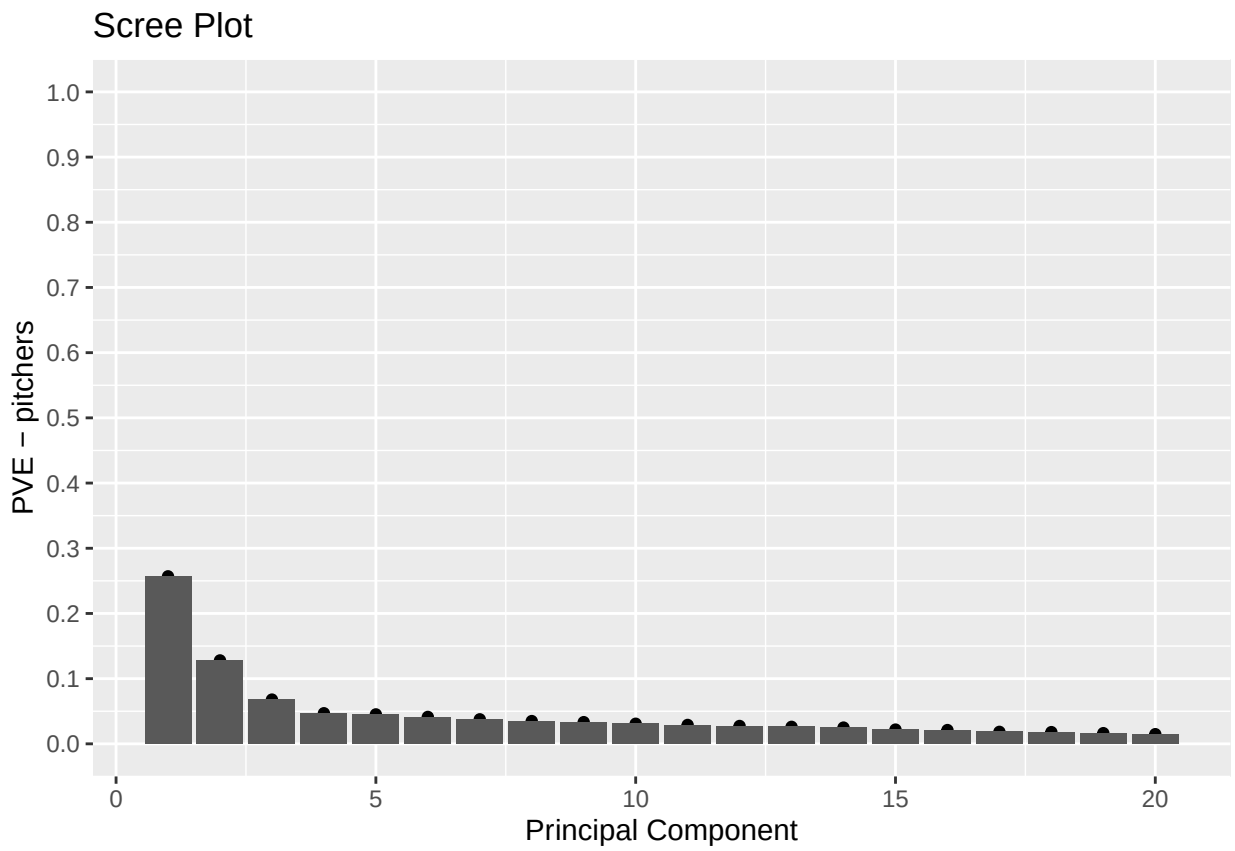
```
##           Name        PC1        PC2       PC3         PC4        PC5       PC6
## 1 A.J. Burnett -0.7073864 -1.5006793 0.3892210  0.57042553  0.3149952 0.3802275
## 2 A.J. Burnett -2.5807611 -1.2578221 0.1097051  0.21058627  0.5107917 0.3346171
## 3 A.J. Burnett -2.5268710 -0.8552628 1.0823492  0.01536254  0.6343113 0.5469413
## 4 A.J. Burnett -0.1597402 -1.1210468 2.1716029 -0.13135818  0.8162257 0.5965805
## 5 A.J. Burnett -0.3927564 -1.1856439 2.8797992 -0.15370215  0.7560155 0.4588448
## 6 A.J. Burnett -0.1958948 -1.4623919 2.0846858 -0.73233606 -0.1666128 1.0206273
```

```r
head(pca_pitchers_advanced$scale^2, n = 6)
```

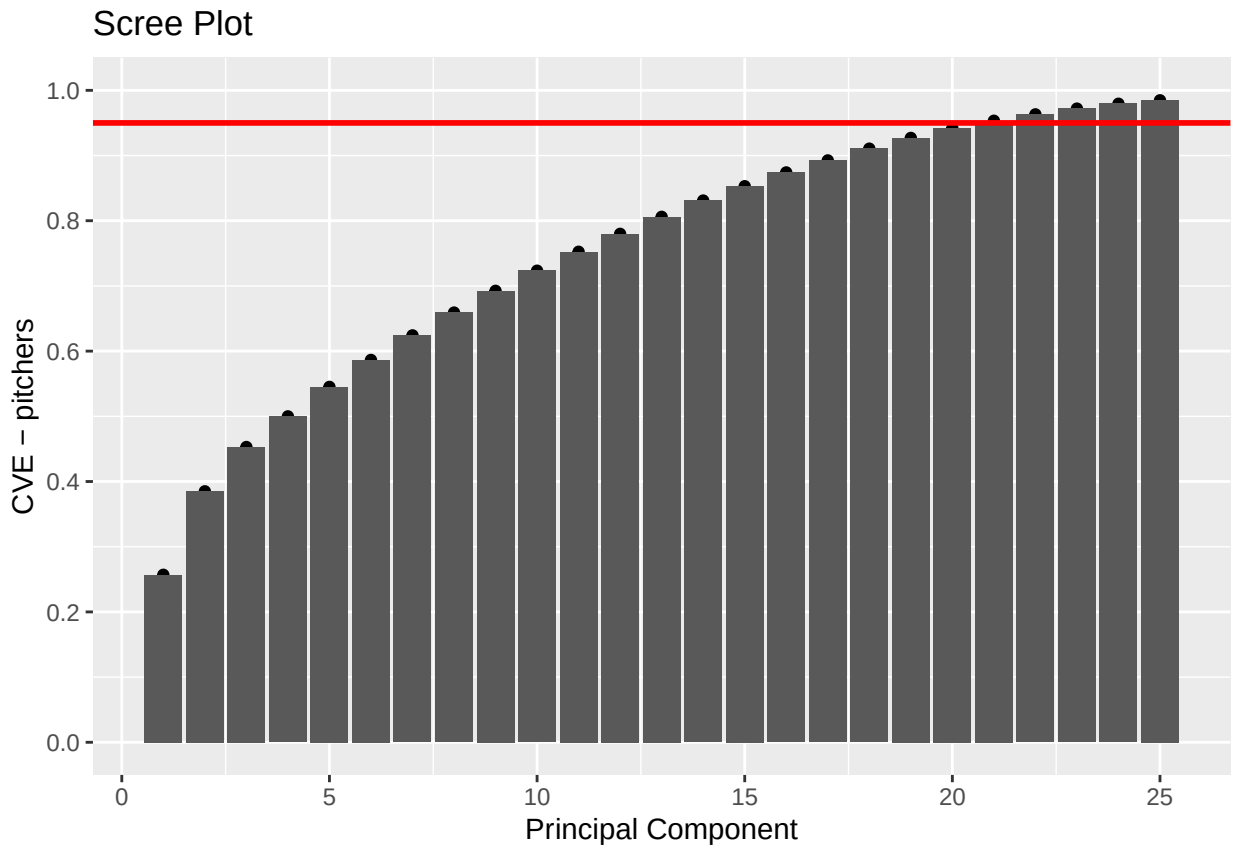
```
##        LOBPercent_3yravg   LDPercent_Pitch_3yravg   GBPercent_Pitch_3yravg
##                35.206658                 7.274295                59.219351
##   FBPercent_Pitch_3yravg SoftPercent_Pitch_3yravg  MedPercent_Pitch_3yravg
```

```
##                56.146732                 9.193243                18.871100
```

```r
# Assigning elements of variability to vectors
PVE = summary(pca_pitchers_advanced)$importance[2,]
CVE = summary(pca_pitchers_advanced)$importance[3,]

# Graph of variability explained
PVEplot <- qplot(c(1:20), PVE[1:20]) +
  geom_bar(stat = "Identity") +
  xlab("Principal Component") +
  ylab("PVE - pitchers") +
  ggtitle("Scree Plot") +
  scale_y_continuous(limits = c(0,1), breaks = seq(0,1,0.1))
PVEplot
```




```r
# Flattens out after the 16th PCA component

CVEplot <- qplot(c(1:25), CVE[1:25]) +
  geom_bar(stat = "Identity") +
  xlab("Principal Component") +
  ylab("CVE - pitchers") +
  ggtitle("Scree Plot") +
  scale_y_continuous(limits = c(0,1), breaks = seq(0,1,0.2)) +
  geom_hline(yintercept = 0.95, color = "red", lwd = 1)
CVEplot
```




```
# Reaches 95% cumulative variability after 21th component

# Adding PCA Components and descriptive values back to dataset
pitchers_advanced = cbind(pitchers_advanced, pca_pitchers_advanced$x[,1:21])
pitchers_advanced = cbind(pitchers[,c(1:6,163:166)], pitchers_advanced)

# Dividing into test and train
pitchers_train = pitchers_advanced[which(pitchers_advanced$playerid %in% pitchers_piselections),]
pitchers_test = pitchers_advanced[which(pitchers_advanced$playerid %!in% pitchers_piselections),]

# Logistic Regression Model
set.seed(2020)
pitchers_glm_advanced = train(
  form = Top100 ~ PC1 + PC2 + PC3 + PC4 + PC5 + PC6 + PC7 + PC8 + PC9 + PC10 + PC11,
  data = pitchers_train,
  trControl = trainControl(method = "cv", number = 10),
  method = "glm",
  family = "binomial"
)

# Model summary
pitchers_glm_advanced
```

```
## Generalized Linear Model
##
## 2789 samples
```

```
##   11 predictor
##    2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 2510, 2510, 2510, 2510, 2510, 2510, ...
## Resampling results:
##
##   Accuracy   Kappa
##   0.9623514  0.6661509
```

```
  # Model values
  pitchers_glm_advanced$finalModel
```

```
##
## Call:  NULL
##
## Coefficients:
## (Intercept)          PC1          PC2          PC3          PC4          PC5
##    -5.20764      0.89189     -0.39039      0.18459     -0.46000      0.38412
##         PC6          PC7          PC8          PC9         PC10         PC11
##     0.30572     -0.11527     -0.06169     -0.29985     -0.13992      0.23161
##
## Degrees of Freedom: 2788 Total (i.e. Null);  2777 Residual
## Null Deviance:       1382
## Residual Deviance: 512.6     AIC: 536.6
```

```
  # Test accuracy
  calc_accuracy_function(pitchers_test$Top100,
                         predict(pitchers_glm_advanced, newdata = pitchers_test))
```

```
## [1] 0.9605588
```

```
  # Dataset to compare predictions vs actual
  pitcherscomp_advanced = cbind(pitchers_train$Name, predict(pitchers_glm_advanced,
                                                             newdata = pitchers_train,
                                                             type = "prob"), pitchers_train$Top100)
  head(pitcherscomp_advanced)
```

```
##   pitchers_train$Name         0           1 pitchers_train$Top100
## 1        A.J. Burnett 0.9906324 0.009367640                     0
## 2        A.J. Burnett 0.9981627 0.001837288                     0
## 3        A.J. Burnett 0.9972427 0.002757340                     0
## 4        A.J. Burnett 0.9768119 0.023188099                     0
## 5        A.J. Burnett 0.9806553 0.019344713                     0
## 6        A.J. Burnett 0.9717015 0.028298516                     0
```

```
  # Confusion Matrix
  pitchers_cm_adv = confusionMatrix(predict(pitchers_glm_advanced, newdata = pitchers_test), pitchers_t
  pitchers_cm_adv$table
```

```
##           Reference
## Prediction    0    1
##          0 1085   31
##          1   17   84
```

Combining PCA Elements and then LR - Batters

Variables Included - all PCA elements from traditional and advanced logistic regression models

```
  # Merging PCA elements to one dataset
  colnames(batters_traditional)[39:54] = gsub("PC", "PC_T", colnames(batters_traditional)[39:54])
  colnames(batters_advanced)[55:77] = gsub("PC", "PC_A", colnames(batters_advanced)[55:77])
  batters_trad_adv = cbind(batters_traditional, batters_advanced)
  # Getting rid of non-PCA columns
  batters_trad_adv = batters_trad_adv[,-c(32:38,55:64)]
  batters_trad_adv = batters_trad_adv[,-c(11:31,48:91)]

  # Dividing into test and train
  batters_train = batters_trad_adv[which(batters_trad_adv$playerid %in% batters_piselections),]
  batters_test = batters_trad_adv[which(batters_trad_adv$playerid %!in% batters_piselections),]

  # Logistic Regression
  set.seed(2020)
  batters_glm_trad_adv = train(
    form = Top100 ~ PC_T1 + PC_T2 + PC_T3 + PC_T4 + PC_T5 + PC_T6 + PC_T7 + PC_T8 + PC_T9 +
      PC_T10 + PC_T11 + PC_T12 + PC_T13 + PC_T14 + PC_T15 + PC_T16 +
      PC_A1 + PC_A2 + PC_A3 + PC_A4 + PC_A5 + PC_A6 + PC_A7+ PC_A8 + PC_A9 + PC_A10 +
      PC_A11 + PC_A12 + PC_A13 + PC_A14 + PC_A15 + PC_A16 + PC_A17 + PC_A18 + PC_A19 + PC_A20 +
      PC_A21 + PC_A22 + PC_A23,
    data = batters_train,
    trControl = trainControl(method = "cv", number = 5),
    method = "glm",
    family = "binomial"
  )

  # Model summary
  batters_glm_trad_adv
```

```
## Generalized Linear Model
##
## 2075 samples
##   39 predictor
##    2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (5 fold)
## Summary of sample sizes: 1659, 1661, 1659, 1660, 1661
## Resampling results:
##
##   Accuracy   Kappa
##   0.9002521  0.7170391
```

```
  # Model values
  batters_glm_trad_adv$finalModel
```

```
##
## Call:  NULL
##
## Coefficients:
## (Intercept)        PC_T1        PC_T2        PC_T3        PC_T4        PC_T5
##    -2.35334      0.84792     -0.05273     -0.72067      0.99056     -1.41780
```

```
##       PC_T6        PC_T7        PC_T8        PC_T9       PC_T10       PC_T11
##     2.42415     -8.65299     -4.21852      3.22315     -6.04481      8.63330
##      PC_T12       PC_T13       PC_T14       PC_T15       PC_T16        PC_A1
##     3.69122     -3.38510     -4.23712      1.23822      0.23763     -0.17952
##       PC_A2        PC_A3        PC_A4        PC_A5        PC_A6        PC_A7
##     0.22872     -0.08555      0.99455     -2.49855     -0.14509      1.54285
##       PC_A8        PC_A9       PC_A10       PC_A11       PC_A12       PC_A13
##    -0.60673     -6.42919     -6.97509     -1.16171      0.96132      1.06363
##      PC_A14       PC_A15       PC_A16       PC_A17       PC_A18       PC_A19
##     4.58548      9.31489     -4.31973     -1.24214     -1.99687     -2.92949
##      PC_A20       PC_A21       PC_A22       PC_A23
##    -4.37549     -1.50067     -1.36792      0.51909
##
## Degrees of Freedom: 2074 Total (i.e. Null);  2035 Residual
## Null Deviance:       2285
## Residual Deviance: 883.1     AIC: 963.1
```

```
  # Test accuracy
  calc_accuracy_function(batters_test$Top100,
                         predict(batters_glm_trad_adv, newdata = batters_test))
```

```
## [1] 0.8792711
```

```
  # Dataset to compare predictions v accuracy
  batterscomp_trad_adv = cbind(batters_train$Name, predict(batters_glm_trad_adv,
                                                           newdata = batters_train,
                                                           type = "prob"), batters_train$Top100)

  head(batterscomp_trad_adv)
```

```
##   batters_train$Name         0          1 batters_train$Top100
## 1         A.J. Ellis 0.9349065 0.06509355                    0
## 2         A.J. Ellis 0.9841825 0.01581747                    0
## 3         A.J. Ellis 0.9890651 0.01093494                    0
## 4    A.J. Pierzynski 0.9795149 0.02048509                    0
## 5    A.J. Pierzynski 0.9821338 0.01786624                    0
## 6    A.J. Pierzynski 0.9405821 0.05941792                    1
```

```
  # Confusion Matrix
  batters_cm_trad_adv = confusionMatrix( predict(batters_glm_trad_adv, newdata = batters_test), batters
  batters_cm_trad_adv$table
```

```
##           Reference
## Prediction   0   1
##          0 637  64
##          1  42 135
```

Combining PCA and then LR - Pitchers

Variables Included - All PCA components from traditional and advanced logistic regression models

```
  # Combining PCA columns to one dataset
  colnames(pitchers_traditional)[35:50] = gsub("PC", "PC_T", colnames(pitchers_traditional)[35:50])
  colnames(pitchers_advanced)[46:66] = gsub("PC", "PC_A", colnames(pitchers_advanced)[46:66])
  pitchers_trad_adv = cbind(pitchers_traditional, pitchers_advanced)
  pitchers_trad_adv = pitchers_trad_adv[,-c(26:34,51:60)]
```

```r
  pitchers_trad_adv = pitchers_trad_adv[,-c(11:25,42:76)]

  # Dividing into test and train
  pitchers_train = pitchers_trad_adv[which(pitchers_trad_adv$playerid %in% pitchers_piselections),]
  pitchers_test = pitchers_trad_adv[which(pitchers_trad_adv$playerid %!in% pitchers_piselections),]

  # Logistic Regression
  set.seed(2020)
  pitchers_glm_trad_adv = train(
    form = Top100 ~ PC_T1 + PC_T2 + PC_T3 + PC_T4 + PC_T5 + PC_T6 + PC_T7 + PC_T8 +
      PC_T9 + PC_T10 + PC_T11 + PC_T12 + PC_T13 + PC_T14 + PC_T15 +
      PC_A1 + PC_A2 + PC_A3 + PC_A4 + PC_A5 + PC_A6 + PC_A7 + PC_A8 + PC_A9 + PC_A10 + PC_A11 +
      PC_A12 + PC_A13 + PC_A14 + PC_A15,
    data = pitchers_train,
    trControl = trainControl(method = "cv", number = 5),
    method = "glm",
    family = "binomial"
  )

  # Model summary
  pitchers_glm_trad_adv
```

```
## Generalized Linear Model
##
## 2789 samples
##   30 predictor
##    2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (5 fold)
## Summary of sample sizes: 2231, 2231, 2232, 2231, 2231
## Resampling results:
##
##   Accuracy   Kappa
##   0.9645007  0.6976765
```

```r
  # Model values
  pitchers_glm_trad_adv$finalModel
```

```
##
## Call:  NULL
##
## Coefficients:
## (Intercept)        PC_T1        PC_T2        PC_T3        PC_T4        PC_T5
##    -6.81233     -1.09911      1.74010      6.54442      0.52452      7.05563
##       PC_T6        PC_T7        PC_T8        PC_T9       PC_T10       PC_T11
##   -19.92486    -11.75328     -1.14180     -3.28097    -10.80626      0.51202
##      PC_T12       PC_T13       PC_T14       PC_T15        PC_A1        PC_A2
##     0.05635     -0.62108     -0.48841      1.08743     -0.24633     -0.07544
##       PC_A3        PC_A4        PC_A5        PC_A6        PC_A7        PC_A8
##     1.05638      1.79793      9.82820     12.04613     -1.40493      1.84088
##       PC_A9       PC_A10       PC_A11       PC_A12       PC_A13       PC_A14
##     7.50453     14.54923     33.98642    -12.32252    -22.28343     -1.62340
##      PC_A15
```

```
##    -3.62574
##
## Degrees of Freedom: 2788 Total (i.e. Null);  2758 Residual
## Null Deviance:       1382
## Residual Deviance: 446.7     AIC: 508.7
```

```
  # Test accuracy
  calc_accuracy_function(pitchers_test$Top100,
                         predict(pitchers_glm_trad_adv, newdata = pitchers_test))
```

```
## [1] 0.9416598
```

```
  # Dataset to compare predictions v accuracy
  pitcherscomp_trad_adv = cbind(pitchers_train$Name, predict(pitchers_glm_trad_adv,
                                                             newdata = pitchers_train,
                                                             type = "prob"), pitchers_train$Top100)

  # Confusion Matrix
  pitchers_cm_trad_adv = confusionMatrix(predict(pitchers_glm_trad_adv, newdata = pitchers_test),pitche
  pitchers_cm_trad_adv
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    0    1
##          0 1080   49
##          1   22   66
##
##                Accuracy : 0.9417
##                  95% CI : (0.927, 0.9542)
##     No Information Rate : 0.9055
##     P-Value [Acc > NIR] : 2.823e-06
##
##                   Kappa : 0.619
##
##  Mcnemar's Test P-Value : 0.002031
##
##             Sensitivity : 0.57391
##             Specificity : 0.98004
##          Pos Pred Value : 0.75000
##          Neg Pred Value : 0.95660
##              Prevalence : 0.09449
##          Detection Rate : 0.05423
##    Detection Prevalence : 0.07231
##       Balanced Accuracy : 0.77697
##
##        'Positive' Class : 1
##
```

Performing PCA on Traditional and Advanced then LR - Batters

Variables Included - All traditional and advanced variables used in PCA

```
  # Merging datasets
  batters_both = cbind(batters_traditional, batters_advanced)
  # Removing name, descriptive values and PCA
```

```r
batters_both = batters_both[,-(55:64)]
batters_both = batters_both[,-c(1:10,39:54,92:121)]

# PCA
pca_batters_both= prcomp(batters_both, scale. = TRUE)
summary(pca_batters_both)
```

```
## Importance of components:
##                           PC1    PC2     PC3     PC4     PC5     PC6     PC7
## Standard deviation     4.4717 2.6949 2.03837 1.98285 1.68254 1.44387 1.37389
## Proportion of Variance 0.3076 0.1117 0.06392 0.06049 0.04355 0.03207 0.02904
## Cumulative Proportion  0.3076 0.4194 0.48329 0.54377 0.58733 0.61940 0.64844
##                           PC8     PC9    PC10   PC11   PC12    PC13    PC14
## Standard deviation     1.31548 1.24101 1.19368 1.1229 1.0635 1.01313 0.99994
## Proportion of Variance 0.02662 0.02369 0.02192 0.0194 0.0174 0.01579 0.01538
## Cumulative Proportion  0.67506 0.69876 0.72068 0.7401 0.7575 0.77327 0.78865
##                           PC15    PC16    PC17    PC18   PC19    PC20    PC21
## Standard deviation     0.98560 0.96801 0.95540 0.94574 0.9157 0.90903 0.85256
## Proportion of Variance 0.01494 0.01442 0.01404 0.01376 0.0129 0.01271 0.01118
## Cumulative Proportion  0.80360 0.81801 0.83205 0.84581 0.8587 0.87143 0.88261
##                           PC22    PC23   PC24    PC25    PC26    PC27    PC28
## Standard deviation     0.81674 0.78901 0.7733 0.75678 0.72760 0.69629 0.69017
## Proportion of Variance 0.01026 0.00958 0.0092 0.00881 0.00814 0.00746 0.00733
## Cumulative Proportion  0.89287 0.90245 0.9116 0.92046 0.92861 0.93607 0.94339
##                           PC29    PC30   PC31   PC32    PC33    PC34    PC35
## Standard deviation     0.67659 0.65125 0.6347 0.6193 0.59093 0.56542 0.48600
## Proportion of Variance 0.00704 0.00652 0.0062 0.0059 0.00537 0.00492 0.00363
## Cumulative Proportion  0.95044 0.95696 0.9632 0.9691 0.97443 0.97935 0.98298
##                           PC36    PC37    PC38   PC39    PC40    PC41    PC42
## Standard deviation     0.41758 0.39648 0.34701 0.3421 0.29531 0.27157 0.25973
## Proportion of Variance 0.00268 0.00242 0.00185 0.0018 0.00134 0.00113 0.00104
## Cumulative Proportion  0.98567 0.98809 0.98994 0.9917 0.99308 0.99422 0.99525
##                           PC43    PC44    PC45    PC46    PC47    PC48    PC49
## Standard deviation     0.23863 0.22077 0.19892 0.19378 0.17167 0.15858 0.13799
## Proportion of Variance 0.00088 0.00075 0.00061 0.00058 0.00045 0.00039 0.00029
## Cumulative Proportion  0.99613 0.99688 0.99749 0.99807 0.99852 0.99891 0.99920
##                           PC50    PC51    PC52    PC53    PC54    PC55    PC56
## Standard deviation     0.11907 0.10507 0.08933 0.08813 0.05879 0.05182 0.03897
## Proportion of Variance 0.00022 0.00017 0.00012 0.00012 0.00005 0.00004 0.00002
## Cumulative Proportion  0.99942 0.99959 0.99971 0.99983 0.99988 0.99992 0.99995
##                           PC57    PC58    PC59    PC60    PC61     PC62
## Standard deviation     0.03409 0.03070 0.02611 0.01985 0.01488 0.005099
## Proportion of Variance 0.00002 0.00001 0.00001 0.00001 0.00000 0.000000
## Cumulative Proportion  0.99996 0.99998 0.99999 1.00000 1.00000 1.000000
##                           PC63     PC64      PC65
## Standard deviation     0.003586 0.001737 1.408e-05
## Proportion of Variance 0.000000 0.000000 0.000e+00
## Cumulative Proportion  1.000000 1.000000 1.000e+00
```

```r
cbind(batters[1:6,1],pca_batters_both$x[1:6,1:6])
```

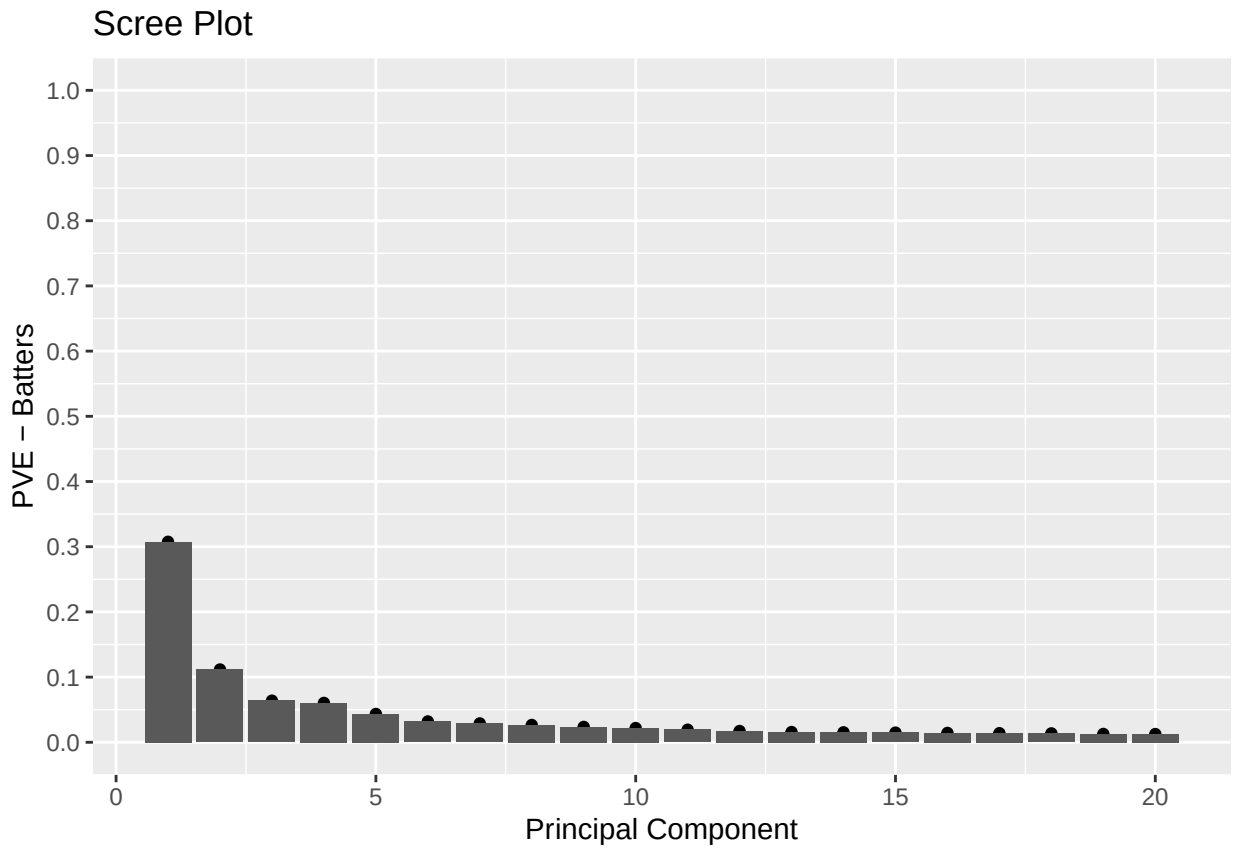
```
##              Name        PC1       PC2       PC3       PC4        PC5
## 1      A.J. Ellis -0.9649128 0.9403676 1.8469182 -1.312280 -1.9560787
## 2      A.J. Ellis -2.5493732 1.6796143 1.2690923 -2.728097 -1.0313977
```

```
## 3      A.J. Ellis -3.6648016 2.2319071 1.0583864 -2.191876 -2.0484016
## 4 A.J. Pierzynski -3.0237490 1.4183354 0.9358940 -2.761832  0.8938653
## 5 A.J. Pierzynski -3.0503865 0.8581999 1.3844129 -3.257367  0.2661191
## 6 A.J. Pierzynski -1.6154950 1.3718762 0.9321839 -2.389565  0.4030617
##           PC6
## 1  0.05887774
## 2  1.05550755
## 3  1.74727064
## 4 -0.26363602
## 5  0.07664955
## 6 -0.07889585
```

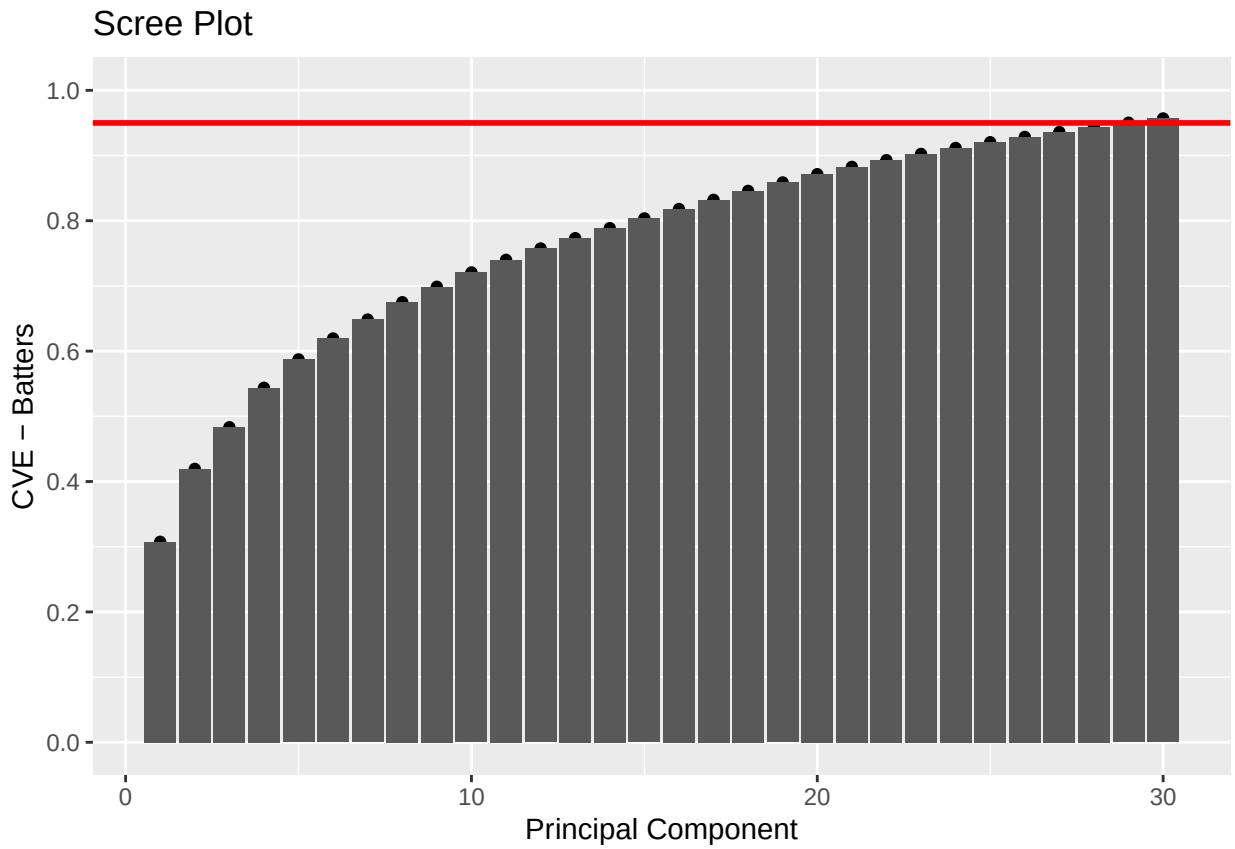
```r
head(pca_batters_both$scale^2, n = 6)
```

```
##   H_Bat_3yravg  BB_Bat_3yravg  SO_Bat_3yravg Doubles_3yravg Triples_3yravg
##    1111.443108     333.499422     918.949093      56.514469       3.732683
##  HR_Bat_3yravg
##      68.971448
```

```r
PVE = summary(pca_batters_both)$importance[2,]
CVE = summary(pca_batters_both)$importance[3,]

# Graph of variability explained
PVEplot <- qplot(c(1:20), PVE[1:20]) +
  geom_bar(stat = "Identity") +
  xlab("Principal Component") +
  ylab("PVE - Batters") +
  ggtitle("Scree Plot") +
  scale_y_continuous(limits = c(0,1), breaks = seq(0,1,0.1))
PVEplot
```




```
# Flattens out after the 15th PCA component

# Graph of cumulative variability explained
CVEplot <- qplot(c(1:30), CVE[1:30]) +
  geom_bar(stat = "Identity") +
  xlab("Principal Component") +
  ylab("CVE - Batters") +
  ggtitle("Scree Plot") +
  scale_y_continuous(limits = c(0,1), breaks = seq(0,1,0.2)) +
  geom_hline(yintercept = 0.95, color = "red", lwd = 1)
CVEplot
```




```
  # Reaches 95% cumulative variability after 29th component

  # Readding pca and descriptive values back to dataset
  batters_both = cbind(batters_both, pca_batters_both$x[,1:29])
  batters_both = cbind(batters[,c(1:6,190:193)], batters_both)

  # Dividing into test and train
  batters_train = batters_both[which(batters_both$playerid %in% batters_piselections),]
  batters_test = batters_both[which(batters_both$playerid %!in% batters_piselections),]

  # Logistic Regression
  set.seed(2020)
  batters_glm_both = train(
    form = Top100 ~ PC1 + PC2 + PC3 + PC4 + PC5 + PC6 + PC7 + PC8 + PC9 + PC10 +
      PC11 + PC12 + PC13 + PC14 + PC15 + PC16 + PC17 + PC18 + PC19 + PC20 +
      PC21 + PC22 + PC23 + PC24 + PC25 + PC26 + PC27 + PC28 + PC29,
    data = batters_train,
    trControl = trainControl(method = "cv", number = 5),
    method = "glm",
    family = "binomial"
  )

  # Model summary
  batters_glm_both
```

```
## Generalized Linear Model
```

```
##
## 2075 samples
##   29 predictor
##    2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (5 fold)
## Summary of sample sizes: 1659, 1661, 1659, 1660, 1661
## Resampling results:
##
##   Accuracy   Kappa
##   0.8973617  0.707637
```

```
  # Model values
  batters_glm_both$finalModel
```

```
##
## Call:  NULL
##
## Coefficients:
## (Intercept)          PC1          PC2          PC3          PC4          PC5
##   -2.314084     0.753649    -0.250169    -0.300000    -0.004515    -0.190674
##         PC6          PC7          PC8          PC9         PC10         PC11
##   -0.091182    -0.012162     0.445395     0.627264    -0.243505     0.203970
##        PC12         PC13         PC14         PC15         PC16         PC17
##   -0.166898    -0.087139     0.156209     0.066097     0.228376     0.383731
##        PC18         PC19         PC20         PC21         PC22         PC23
##   -0.078768     0.004037    -0.252510    -0.293881     0.203482    -0.109316
##        PC24         PC25         PC26         PC27         PC28         PC29
##    0.179604     0.269187     0.152504    -0.221730    -0.170037    -0.144052
##
## Degrees of Freedom: 2074 Total (i.e. Null);  2045 Residual
## Null Deviance:       2285
## Residual Deviance: 910.1     AIC: 970.1
```

```
  # Test accuracy
  calc_accuracy_function(batters_test$Top100,
                         predict(batters_glm_both, newdata = batters_test))
```

```
## [1] 0.8849658
```

```
  # Dataset to compare predictions with actual
  batterscomp_both = cbind(batters_train$Name, predict(batters_glm_both,
                                                       newdata = batters_train,
                                                       type = "prob"), batters_train$Top100)
  head(batterscomp_both)
```

```
##   batters_train$Name         0          1 batters_train$Top100
## 1         A.J. Ellis 0.9074176 0.09258239                    0
## 2         A.J. Ellis 0.9740629 0.02593714                    0
## 3         A.J. Ellis 0.9828705 0.01712955                    0
## 4    A.J. Pierzynski 0.9786075 0.02139251                    0
## 5    A.J. Pierzynski 0.9819264 0.01807362                    0
## 6    A.J. Pierzynski 0.9557364 0.04426357                    1
```

```
  # Confusion Matrix
  batters_cm_both = confusionMatrix(predict(batters_glm_both, newdata = batters_test),batters_test$Top1
```

```
batters_cm_both$table
```

```
##            Reference
## Prediction   0   1
##          0 638  60
##          1  41 139
```

Performing PCA on Traditional and Advanced, then LR - Pitchers

Variables Included - All traditional and advanced variables from PCA

```
# Combining dataset
pitchers_both = cbind(pitchers_traditional, pitchers_advanced)
# Removing unnecessary variables
pitchers_both = pitchers_both[,-(51:60)]
pitchers_both = pitchers_both[,-c(1:10,35:50,77:106)]

# PCA
pca_pitchers_both= prcomp(pitchers_both, scale. = TRUE)
summary(pca_pitchers_both)
```

```
## Importance of components:
##                           PC1    PC2     PC3     PC4     PC5     PC6     PC7
## Standard deviation     3.449 3.0177 1.67387 1.55090 1.42606 1.33177 1.27954
## Proportion of Variance 0.238 0.1821 0.05604 0.04811 0.04067 0.03547 0.03274
## Cumulative Proportion  0.238 0.4201 0.47612 0.52423 0.56490 0.60037 0.63312
##                           PC8     PC9    PC10    PC11    PC12    PC13    PC14
## Standard deviation     1.19724 1.13627 1.11144 1.05628 1.01704 1.00159 0.98281
## Proportion of Variance 0.02867 0.02582 0.02471 0.02231 0.02069 0.02006 0.01932
## Cumulative Proportion  0.66179 0.68761 0.71231 0.73463 0.75532 0.77538 0.79470
##                           PC15    PC16    PC17    PC18    PC19    PC20    PC21
## Standard deviation     0.95765 0.94384 0.89864 0.88489 0.87518 0.85123 0.81223
## Proportion of Variance 0.01834 0.01782 0.01615 0.01566 0.01532 0.01449 0.01319
## Cumulative Proportion  0.81304 0.83086 0.84701 0.86267 0.87799 0.89248 0.90567
##                           PC22    PC23    PC24    PC25    PC26    PC27    PC28
## Standard deviation     0.79527 0.78160 0.72295 0.65276 0.60031 0.58680 0.56465
## Proportion of Variance 0.01265 0.01222 0.01045 0.00852 0.00721 0.00689 0.00638
## Cumulative Proportion  0.91832 0.93054 0.94099 0.94952 0.95672 0.96361 0.96999
##                           PC29    PC30    PC31    PC32    PC33    PC34    PC35
## Standard deviation     0.51914 0.43301 0.41927 0.40082 0.37033 0.36379 0.30868
## Proportion of Variance 0.00539 0.00375 0.00352 0.00321 0.00274 0.00265 0.00191
## Cumulative Proportion  0.97538 0.97913 0.98264 0.98586 0.98860 0.99124 0.99315
##                           PC36    PC37    PC38    PC39    PC40    PC41    PC42
## Standard deviation     0.26868 0.25287 0.22058 0.19044 0.17956 0.16909 0.14406
## Proportion of Variance 0.00144 0.00128 0.00097 0.00073 0.00064 0.00057 0.00042
## Cumulative Proportion  0.99459 0.99587 0.99685 0.99757 0.99822 0.99879 0.99920
##                           PC43    PC44    PC45    PC46    PC47    PC48    PC49
## Standard deviation     0.09886 0.09079 0.08608 0.07644 0.05488 0.05224 0.04188
## Proportion of Variance 0.00020 0.00016 0.00015 0.00012 0.00006 0.00005 0.00004
## Cumulative Proportion  0.99940 0.99956 0.99971 0.99983 0.99989 0.99994 0.99998
##                           PC50
## Standard deviation     0.03259
## Proportion of Variance 0.00002
## Cumulative Proportion  1.00000
```

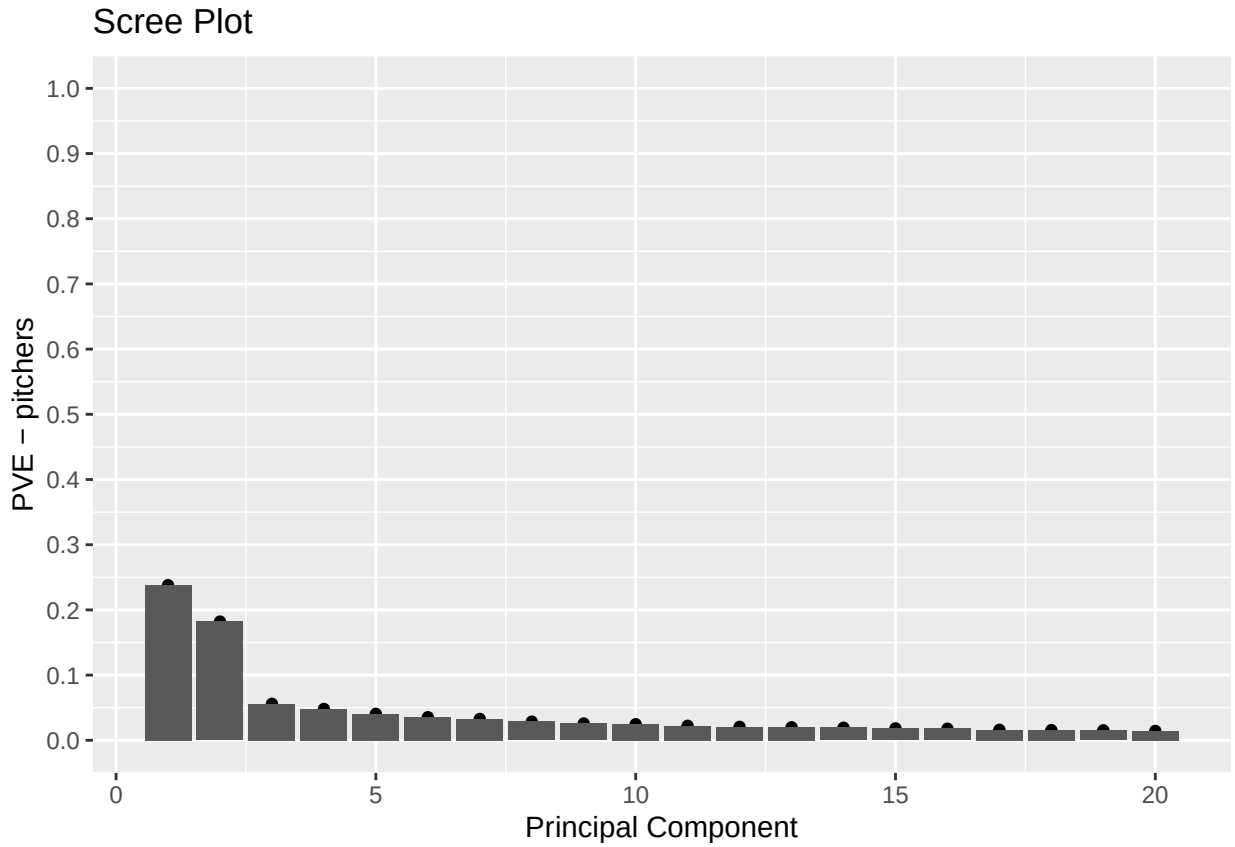
```r
  cbind(pitchers[1:6,1],pca_pitchers_both$x[1:6,1:6])
```

```
##           Name       PC1       PC2        PC3        PC4      PC5        PC6
## 1 A.J. Burnett 1.2778064 -4.637432 -0.6869763 -0.3462696 2.077797 -1.5628780
## 2 A.J. Burnett 3.2350875 -4.018696 -0.4089534 -0.8549426 2.410232 -1.5479390
## 3 A.J. Burnett 2.8455141 -4.046194 -1.4637225 -0.8959427 2.725041 -1.4092599
## 4 A.J. Burnett 0.2328886 -3.932835 -2.2719223 -0.6152020 1.927585 -0.4288666
## 5 A.J. Burnett 0.2974220 -4.234683 -3.1595617 -0.5027763 2.366608 -0.4087474
## 6 A.J. Burnett 0.2418791 -3.513682 -2.2255082 -0.2099395 2.388875  0.2187822
```

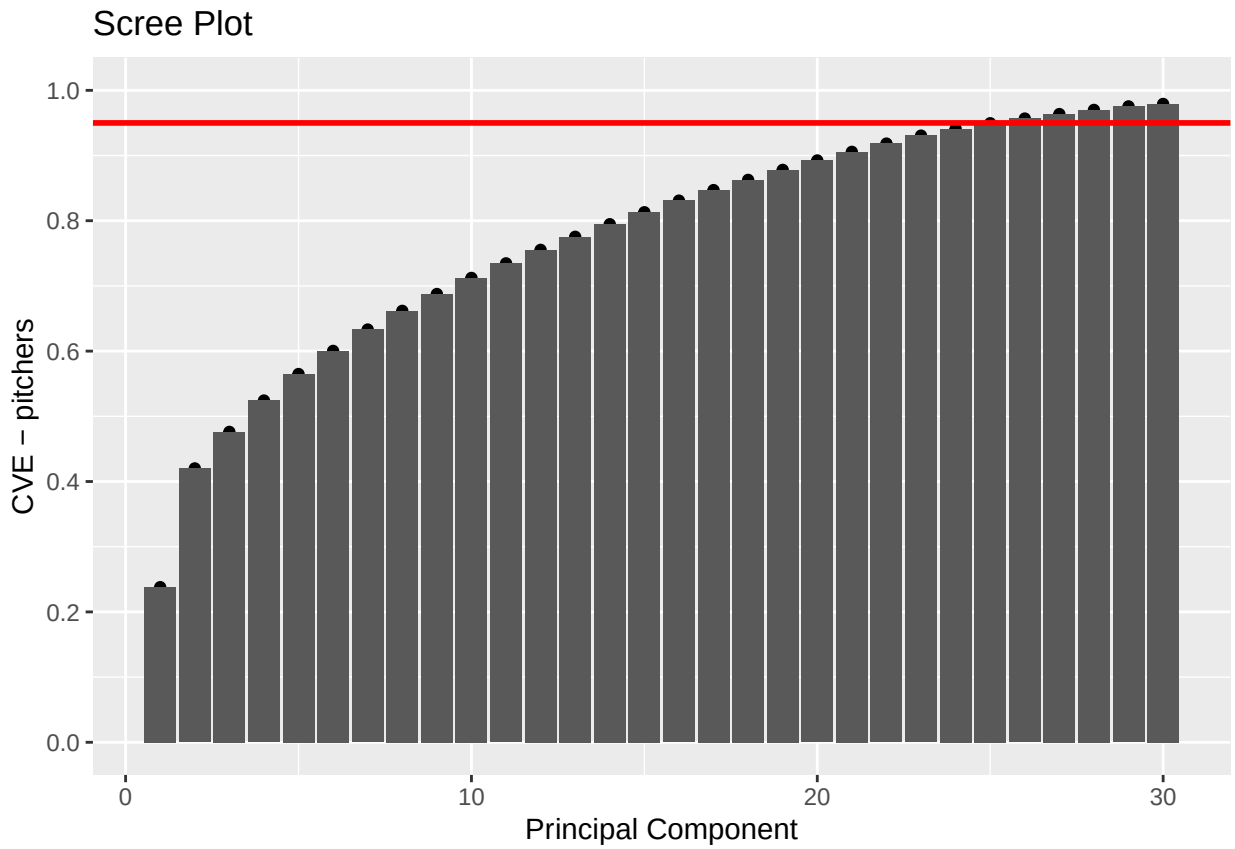
```r
  head(pca_pitchers_both$scale^2, n = 6)
```

```
##       W_3yravg       L_3yravg      CG_3yravg     SHO_3yravg      SV_3yravg
##   1.371911e+01   8.998276e+00   4.124620e-01   9.723845e-02   5.121191e+01
## H_Pitch_3yravg
##   2.439816e+03
```

```r
  PVE = summary(pca_pitchers_both)$importance[2,]
  CVE = summary(pca_pitchers_both)$importance[3,]

  # Graph of variability explained
  PVEplot <- qplot(c(1:20), PVE[1:20]) +
    geom_bar(stat = "Identity") +
    xlab("Principal Component") +
    ylab("PVE - pitchers") +
    ggtitle("Scree Plot") +
    scale_y_continuous(limits = c(0,1), breaks = seq(0,1,0.1))
  PVEplot
```




```
# Flattens out after the 15th PCA component

# Graph of cumulative variability explained
CVEplot <- qplot(c(1:30), CVE[1:30]) +
  geom_bar(stat = "Identity") +
  xlab("Principal Component") +
  ylab("CVE - pitchers") +
  ggtitle("Scree Plot") +
  scale_y_continuous(limits = c(0,1), breaks = seq(0,1,0.2)) +
  geom_hline(yintercept = 0.95, color = "red", lwd = 1)
CVEplot
```




```
  # Reaches 95% cumulative variability after 26th component

  # Adding PCA components and descriptive statistics back to dataset
  pitchers_both = cbind(pitchers_both, pca_pitchers_both$x[,1:26])
  pitchers_both = cbind(pitchers[,c(1:6,163:166)], pitchers_both)

  # Dividing into test and train
  pitchers_train = pitchers_both[which(pitchers_both$playerid %in% pitchers_piselections),]
  pitchers_test = pitchers_both[which(pitchers_both$playerid %!in% pitchers_piselections),]

  # Logistic Regression
  set.seed(2020)
  pitchers_glm_both = train(
    form = Top100 ~ PC1 + PC2 + PC3 + PC4 + PC5 + PC6 + PC7 + PC8 + PC9 + PC10 +
      PC11 + PC12 + PC13 + PC14 + PC15 + PC16 + PC17 + PC18 + PC19 + PC20 + PC21,
    data = pitchers_train,
    trControl = trainControl(method = "cv", number = 5),
    method = "glm",
    family = "binomial"
  )

  # Model summary
  pitchers_glm_both
```

```
## Generalized Linear Model
##
```

```
## 2789 samples
##   21 predictor
##    2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (5 fold)
## Summary of sample sizes: 2231, 2231, 2232, 2231, 2231
## Resampling results:
##
##   Accuracy   Kappa
##   0.9601977  0.6610727
```

```
  # Model values
  pitchers_glm_both$finalModel
```

```
##
## Call:  NULL
##
## Coefficients:
## (Intercept)          PC1          PC2          PC3          PC4          PC5
##   -5.558541    -0.747519    -0.342441    -0.033681     0.211137     0.002337
##         PC6          PC7          PC8          PC9         PC10         PC11
##    0.284047    -0.244511     0.893644    -0.603370    -0.623575     0.172424
##        PC12         PC13         PC14         PC15         PC16         PC17
##    2.051121    -4.862809    -1.710655     0.586242     0.547346     0.495950
##        PC18         PC19         PC20         PC21
##   -0.239995    -0.014010     0.276579     0.090890
##
## Degrees of Freedom: 2788 Total (i.e. Null);  2767 Residual
## Null Deviance:       1382
## Residual Deviance: 478.4     AIC: 522.4
```

```
  # Test accuracy
  calc_accuracy_function(pitchers_test$Top100,
                         predict(pitchers_glm_both, newdata = pitchers_test))
```

```
## [1] 0.9498767
```

```
  # Dataset to compare predictions with accuracy
  pitcherscomp_both = cbind(pitchers_train$Name, predict(pitchers_glm_both,
                                                         newdata = pitchers_train,
                                                         type = "prob"), pitchers_train$Top100)
  head(pitcherscomp_both)
```

```
##   pitchers_train$Name         0           1 pitchers_train$Top100
## 1        A.J. Burnett 0.9825922 0.017407784                      0
## 2        A.J. Burnett 0.9965490 0.003450963                      0
## 3        A.J. Burnett 0.9936781 0.006321916                      0
## 4        A.J. Burnett 0.9671231 0.032876937                      0
## 5        A.J. Burnett 0.9765291 0.023470896                      0
## 6        A.J. Burnett 0.9621132 0.037886839                      0
```

```
  # Confusion Matrix
  pitchers_cm_both = confusionMatrix(predict(pitchers_glm_both, newdata = pitchers_test), pitchers_test$
  pitchers_cm_both$table
```

```
##           Reference
```

```
## Prediction    0    1
##          0 1085   44
##          1   17   71
```

PCA Results

```
cmlist = list(batters_cm_trad$table, pitchers_cm_trad$table,
              batters_cm_adv$table, pitchers_cm_adv$table,
              batters_cm_trad_adv$table, pitchers_cm_trad_adv$table,
              batters_cm_both$table, pitchers_cm_both$table)

get_confusion_matrix_function = function(cmlist){
  tablelist = list()
  for(i in 1:length(cmlist)){
    tablelist[[i]] = as.data.frame(cmlist[[i]])
    tablelist[[i]] = tablelist[[i]] %>%
  mutate(goodbad = ifelse(tablelist[[i]]$Prediction == tablelist[[i]]$Reference, "correct", "incorrect")
  group_by(Reference) %>%
  mutate(prop = Freq/sum(Freq))
  }
  tablelist
}

cmlist = get_confusion_matrix_function(cmlist)
```

```
batters_cm_trad_plot = ggplot(data = cmlist[[1]], mapping = aes(x = Reference, y = Prediction, fill = g
  geom_tile() +
  geom_text(aes(label = Freq), vjust = .5, fontface  = "bold", alpha = 1) +
  scale_fill_manual(values = c(correct = "green", incorrect = "red")) +
  theme_bw() +
  labs(fill = "Quality of Prediction", alpha = "Proportion") +
  ggtitle("CM for Traditional Variables - Batters") +
  theme(plot.title = element_text(hjust = 0.5))
```

```
pitchers_cm_trad_plot = ggplot(data = cmlist[[2]], mapping = aes(x = Reference, y = Prediction, fill = g
  geom_tile() +
  geom_text(aes(label = Freq), vjust = .5, fontface  = "bold", alpha = 1) +
  scale_fill_manual(values = c(correct = "green", incorrect = "red")) +
  theme_bw() +
  labs(fill = "Quality of Prediction", alpha = "Proportion") +
  ggtitle("CM for Traditional Variables - Pitchers") +
  theme(plot.title = element_text(hjust = 0.5))
```

```
batters_cm_adv_plot = ggplot(data = cmlist[[3]], mapping = aes(x = Reference, y = Prediction, fill = goo
  geom_tile() +
  geom_text(aes(label = Freq), vjust = .5, fontface  = "bold", alpha = 1) +
  scale_fill_manual(values = c(correct = "green", incorrect = "red")) +
  theme_bw() +
  labs(fill = "Quality of Prediction", alpha = "Proportion") +
  ggtitle("CM for Advanced Variables - Batters") +
  theme(plot.title = element_text(hjust = 0.5))
```

```
pitchers_cm_adv_plot = ggplot(data = cmlist[[4]], mapping = aes(x = Reference, y = Prediction, fill = g
  geom_tile() +
```

```
  geom_text(aes(label = Freq), vjust = .5, fontface  = "bold", alpha = 1) +
  scale_fill_manual(values = c(correct = "green", incorrect = "red")) +
  theme_bw() +
  labs(fill = "Quality of Prediction", alpha = "Proportion") +
  ggtitle("CM for Advanced Variables - Pitchers") +
  theme(plot.title = element_text(hjust = 0.5))
```

```
batters_cm_trad_adv_plot = ggplot(data = cmlist[[5]], mapping = aes(x = Reference, y = Prediction, fill
  geom_tile() +
  geom_text(aes(label = Freq), vjust = .5, fontface  = "bold", alpha = 1) +
  scale_fill_manual(values = c(correct = "green", incorrect = "red")) +
  theme_bw() +
  labs(fill = "Quality of Prediction", alpha = "Proportion") +
   ggtitle("CM for Traditional & Advanced PCA - Batters") +
   theme(plot.title = element_text(hjust = 0.5))
```

```
pitchers_cm_trad_adv_plot = ggplot(data = cmlist[[6]], mapping = aes(x = Reference, y = Prediction, fil
  geom_tile() +
  geom_text(aes(label = Freq), vjust = .5, fontface  = "bold", alpha = 1) +
  scale_fill_manual(values = c(correct = "green", incorrect = "red")) +
  theme_bw() +
  labs(fill = "Quality of Prediction", alpha = "Proportion") +
  ggtitle("CM for Traditional & Advanced PCA - Pitchers") +
  theme(plot.title = element_text(hjust = 0.5))
```

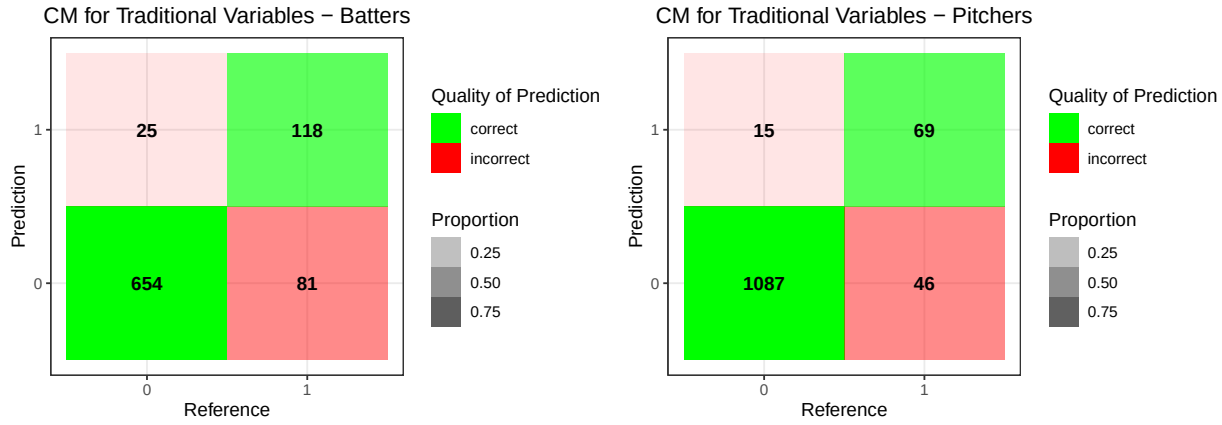
```
batters_cm_both_plot = ggplot(data = cmlist[[7]], mapping = aes(x = Reference, y = Prediction, fill = g
  geom_tile() +
  geom_text(aes(label = Freq), vjust = .5, fontface  = "bold", alpha = 1) +
  scale_fill_manual(values = c(correct = "green", incorrect = "red")) +
  theme_bw() +
  labs(fill = "Quality of Prediction", alpha = "Proportion") +
  ggtitle("CM for Traditional & Advanced Variables - Batters") +
  theme(plot.title = element_text(hjust = 0.5))
```

```
pitchers_cm_both_plot = ggplot(data = cmlist[[8]], mapping = aes(x = Reference, y = Prediction, fill = g
  geom_tile() +
  geom_text(aes(label = Freq), vjust = .5, fontface  = "bold", alpha = 1) +
  scale_fill_manual(values = c(correct = "green", incorrect = "red")) +
  theme_bw() +
  labs(fill = "Quality of Prediction", alpha = "Proportion") +
  ggtitle("CM for Traditional & Advanced Variables - Pitchers") +
  theme(plot.title = element_text(hjust = 0.5))
```

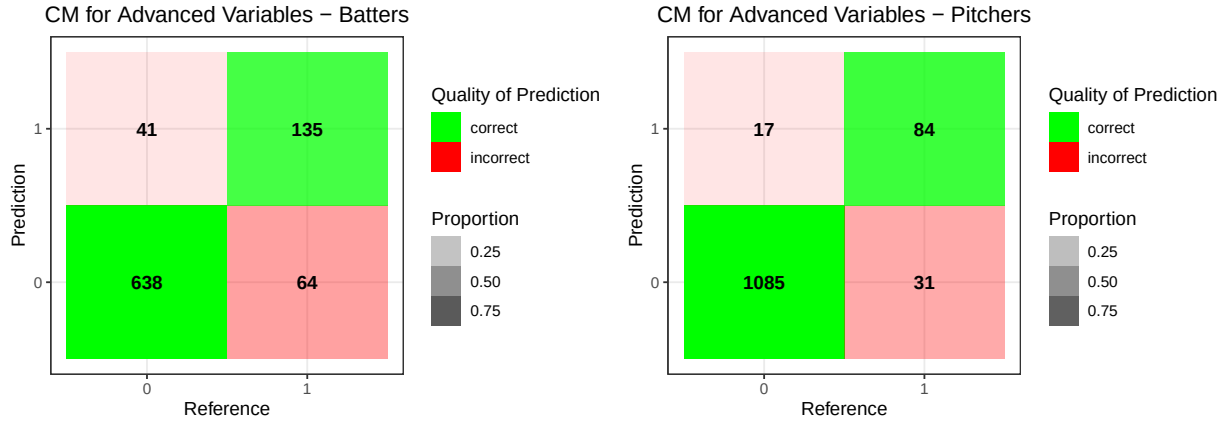
```
library(cowplot)
```

```
## Warning: package 'cowplot' was built under R version 4.0.3
```

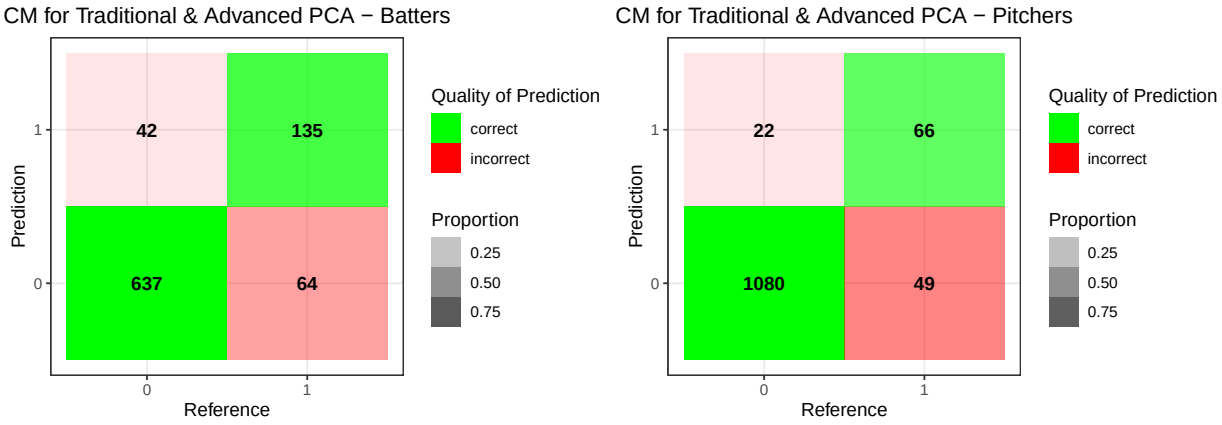
```
plot_grid(batters_cm_trad_plot,
pitchers_cm_trad_plot,
batters_cm_adv_plot,
pitchers_cm_adv_plot,
batters_cm_trad_adv_plot,
pitchers_cm_trad_adv_plot,
batters_cm_both_plot,
pitchers_cm_both_plot, nrow = 4, ncol = 2)
```


CM for Traditional Variables − Batters
25
118
654
81
Prediction
Reference
Quality of Prediction
correct
incorrect
Proportion
0.25
0.50
0.75

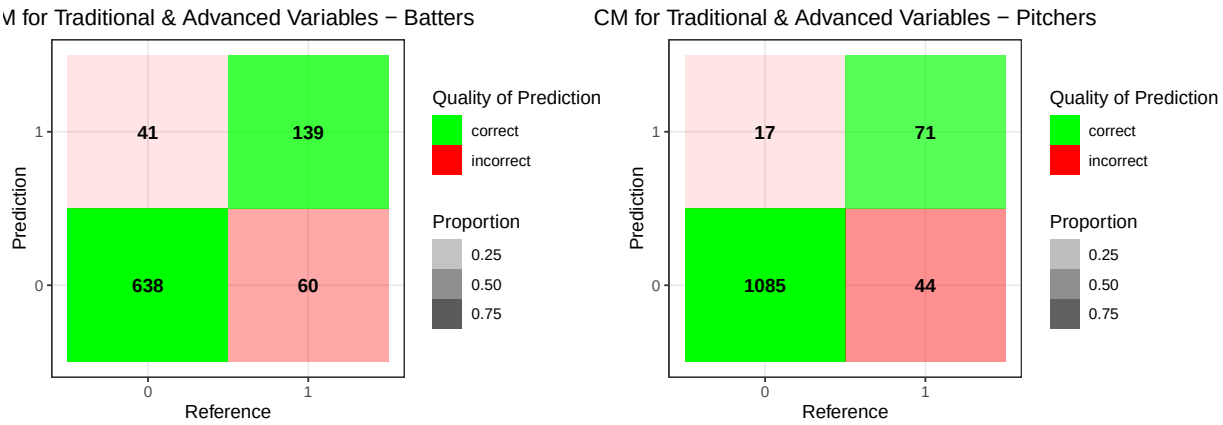
CM for Traditional Variables − Pitchers
15
69
1087
46
Prediction
Reference
Quality of Prediction
correct
incorrect
Proportion
0.25
0.50
0.75


CM for Advanced Variables − Batters
41
135
638
64
Prediction
Reference
Quality of Prediction
correct
incorrect
Proportion
0.25
0.50
0.75

CM for Advanced Variables − Pitchers
17
84
1085
31
Prediction
Reference
Quality of Prediction
correct
incorrect
Proportion
0.25
0.50
0.75


CM for Traditional & Advanced PCA − Batters
42
135
637
64
Prediction
Reference
Quality of Prediction
correct
incorrect
Proportion
0.25
0.50
0.75

CM for Traditional & Advanced PCA − Pitchers
22
66
1080
49
Prediction
Reference
Quality of Prediction
correct
incorrect
Proportion
0.25
0.50
0.75


M for Traditional & Advanced Variables − Batters
41
139
638
60
Prediction
Reference
Quality of Prediction
correct
incorrect
Proportion
0.25
0.50
0.75

CM for Traditional & Advanced Variables − Pitchers
17
71
1085
44
Prediction
Reference
Quality of Prediction
correct
incorrect
Proportion
0.25
0.50
0.75

```
tablelist =  list(batters_cm_trad, batters_cm_adv,batters_cm_trad_adv, batters_cm_both,
                  pitchers_cm_trad, pitchers_cm_adv, pitchers_cm_trad_adv, pitchers_cm_both)

cm_accuracy = rep(NA,8)
cm_sensitivity = rep(NA,8)
cm_specificity = rep(NA,8)
cm_pospredvalue = rep(NA,8)
cm_negpredvalue = rep(NA,8)

for(i in 1:8){
  cm_accuracy[i] = round(tablelist[[i]]$overall['Accuracy'],3)
  cm_sensitivity[i] = round(tablelist[[i]]$byClass['Sensitivity'],3)
  cm_specificity[i] = round(tablelist[[i]]$byClass['Specificity'],3)
  cm_pospredvalue[i] = round(tablelist[[i]]$byClass['Pos Pred Value'],3)
  cm_negpredvalue[i] = round(tablelist[[i]]$byClass['Neg Pred Value'],3)
}

cm_names = c("Batters Traditional PCA", "Batters Advanced PCA", "Mix of Batters Trad/Adv PCA",
             "Batters Trad/Adv then PCA", "Pitchers Traditional PCA", "Pitchers Advanced PCA", "Mix of P

cm_table = as.data.frame(cbind(cm_names, cm_accuracy, cm_sensitivity, cm_specificity,cm_pospredvalue, cm
colnames(cm_table) = c("Method", "Accuracy", "Sensitivity", "Specificity", "Positive PV", "Negative PV")
library(kableExtra)
```

```
## Warning: package 'kableExtra' was built under R version 4.0.3
```

```
##
## Attaching package: 'kableExtra'
```

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

```
kable(cm_table)
```

Method	Accuracy	Sensitivity	Specificity	Positive PV	Negative PV
Batters Traditional PCA	0.879	0.593	0.963	0.825	0.89
Batters Advanced PCA	0.88	0.678	0.94	0.767	0.909
Mix of Batters Trad/Adv PCA	0.879	0.678	0.938	0.763	0.909
Batters Trad/Adv then PCA	0.885	0.698	0.94	0.772	0.914
Pitchers Traditional PCA	0.95	0.6	0.986	0.821	0.959
Pitchers Advanced PCA	0.961	0.73	0.985	0.832	0.972
Mix of Pitchers Trad/Adv PCA	0.942	0.574	0.98	0.75	0.957
Pitchers Trad/Adv then PCA	0.95	0.617	0.985	0.807	0.961

Penalized Regression Models

```
library(glmnet)
 # Selecting variables
  batters_traditional = batters_active[,c(4:15,46:47,31,57:62,68:72,75:76)]
  batters_traditional = cbind(batters[,c(1:6,191:193,190)],batters_traditional)

  # Dividing into test and train
  batters_train = batters_traditional[which(batters_traditional$playerid %in% batters_piselections),]
  batters_test = batters_traditional[which(batters_traditional$playerid %!in% batters_piselections),]
```

```r
# Removing variables not in model
train_dv = batters_train[,c(1:9)]
test_dv = batters_test[,c(1:9)]
batters_train = batters_train[,-c(1:9)]
batters_test = batters_test[,-c(1:9)]

# Penalized logistic regression model
set.seed(2020)
cv_10 = trainControl(method = "cv", number = 10)

batters_traditional_plr_model <- train(form = Top100 ~ ., data = batters_train,
                            method = "glmnet",
                            family = "binomial",
                            trControl = cv_10,
                            tuneGrid = expand.grid(alpha = 1,
                                                   lambda = seq(0.001,0.1,by = 0.001)))

# Best lambda value
batters_traditional_plr_model$bestTune
```

```
##   alpha lambda
## 2     1  0.002
```

```r
# Coefficients at that lambda value
round(coef(batters_traditional_plr_model$finalModel, batters_traditional_plr_model$bestTune$lambda),3
```

```
## 29 x 1 sparse Matrix of class "dgCMatrix"
##                              1
## (Intercept)          -16.837
## H_Bat_3yravg           .
## BB_Bat_3yravg         -0.017
## SO_Bat_3yravg         -0.010
## Doubles_3yravg         0.023
## Triples_3yravg         0.068
## HR_Bat_3yravg          0.155
## TB_3yravg              0.001
## RBI_3yravg            -0.003
## BA_3yravg              .
## OBP_3yravg            30.008
## SLG_3yravg             .
## OPS_3yravg             1.473
## SB_3yravg              0.053
## CS_3yravg              .
## RCPerG_3yravg          0.225
## PO_3yravg              0.001
## A_3yravg               0.006
## E_3yravg               0.002
## DP_3yravg             -0.020
## FldPercent_3yravg      .
## RFPer9_3yravg          0.040
## AllStar_total          0.127
## GoldGlove_total        0.061
## SilverSlugger_total    0.121
## MVPRank_3yravg        -0.006
```

```
## MVPVotePoints_3yravg   0.013
## ROYRank_3yravg         0.012
## ROYVotePoints_3yravg   0.020
```

```
  # Test data accuracy
  calc_accuracy_function(batters_test$Top100,
                         predict(batters_traditional_plr_model, newdata = batters_test,
                                 s = batters_traditional_plr_model$bestTune$lambda))
```

```
## [1] 0.88041
```

```
  batters_train = cbind(train_dv[,1:9], batters_train[,1], batters_train[,2:29])
  colnames(batters_train)[10] = "Top100"

  # Dataset of predictions v actual
  batterscomp_plr_traditional = cbind(batters_train$Name, batters_train$Season,
                                      predict(batters_traditional_plr_model,
                                      newdata = batters_train,
                                      s = batters_traditional_plr_model$bestTune$lambda,
                                      type = "prob"), batters_train$Top100)
  head(batterscomp_plr_traditional)
```

```
##   batters_train$Name batters_train$Season         0          1
## 1         A.J. Ellis                 2013 0.9019496 0.09805044
## 2         A.J. Ellis                 2014 0.9574791 0.04252091
## 3         A.J. Ellis                 2015 0.9712042 0.02879580
## 4    A.J. Pierzynski                 2010 0.8926171 0.10738286
## 5    A.J. Pierzynski                 2011 0.8991142 0.10088584
## 6    A.J. Pierzynski                 2012 0.8083628 0.19163722
##   batters_train$Top100
## 1                    0
## 2                    0
## 3                    0
## 4                    0
## 5                    0
## 6                    1
```

```
  # Confusion matrix
  batters_cm_plr_trad = confusionMatrix(predict(batters_traditional_plr_model,
                                                newdata = batters_test,
                                                s = batters_traditional_plr_model$bestTune$lambda),
                                                batters_test$Top100, positive='1')
  batters_cm_plr_trad$table
```

```
##           Reference
## Prediction   0   1
##          0 652  78
##          1  27 121
```

```
library(glmnet)
 # Selecting variables
  pitchers_traditional = pitchers_active[,c(1:2,5:7,13:18,20:23,50:54,57:58,61:62)]
  pitchers_traditional = cbind(pitchers[,c(1:6,164:166,163)], pitchers_traditional)

  # Dividing into test and train
  pitchers_train = pitchers_traditional[which(pitchers_traditional$playerid %in% pitchers_piselections)
  pitchers_test = pitchers_traditional[which(pitchers_traditional$playerid %!in% pitchers_piselections)
```

```r
# Removing variables not in model
train_dv = pitchers_train[,c(1:9)]
test_dv = pitchers_test[,c(1:9)]
pitchers_train = pitchers_train[,-c(1:9)]
pitchers_test = pitchers_test[,-c(1:9)]

# Penalized logistic regression model
set.seed(2020)
cv_10 = trainControl(method = "cv", number = 10)

pitchers_traditional_plr_model <- train(form = Top100 ~ ., data = pitchers_train,
                            method = "glmnet",
                            family = "binomial",
                            trControl = cv_10,
                            tuneGrid = expand.grid(alpha = 1,
                                                   lambda = seq(0.001,0.1,by = 0.001)))

# Best lambda value
pitchers_traditional_plr_model$bestTune
```

```
##   alpha lambda
## 2     1  0.002
```

```r
# Coefficients at that lambda value
round(coef(pitchers_traditional_plr_model$finalModel, pitchers_traditional_plr_model$bestTune$lambda),3)
```

```
## 25 x 1 sparse Matrix of class "dgCMatrix"
##                              1
## (Intercept)          -0.389
## W_3yravg              0.192
## L_3yravg             -0.003
## CG_3yravg             0.321
## SHO_3yravg            0.246
## SV_3yravg             0.015
## H_Pitch_3yravg        .
## R_Pitch_3yravg        .
## ER_3yravg             .
## ERA_3yravg            .
## WHIP_3yravg          -3.441
## RSPer9_3yravg         .
## HR9_3yravg           -1.723
## BB9_3yravg            .
## SO9_3yravg            0.366
## RA9_3yravg           -0.368
## AllStar_total         0.152
## GoldGlove_total      -1.486
## SilverSlugger_total   .
## MVPRank_3yravg       -1.007
## MVPVotePoints_3yravg  .
## CYRank_3yravg         0.233
## CYVotePoints_3yravg   0.017
## ROYRank_3yravg        0.192
## ROYVotePoints_3yravg  0.007
```

```r
  # Test data accuracy
  calc_accuracy_function(pitchers_test$Top100,
                         predict(pitchers_traditional_plr_model, newdata = pitchers_test,
                                 s = pitchers_traditional_plr_model$bestTune$lambda))
```

```
## [1] 0.94659
```

```r
  pitchers_train = cbind(train_dv[,1:9], pitchers_train[,1], pitchers_train[,2:25])
  colnames(pitchers_train)[10] = "Top100"

  # Dataset of predictions v actual
  pitcherscomp_plr_traditional = cbind(pitchers_train$Name, pitchers_train$Season,
                                       predict(pitchers_traditional_plr_model,
                                       newdata = pitchers_train,
                                       s = pitchers_traditional_plr_model$bestTune$lambda,
                                       type = "prob"), pitchers_train$Top100)
  head(pitcherscomp_plr_traditional)
```

```
##   pitchers_train$Name pitchers_train$Season         0          1
## 1        A.J. Burnett                  2010 0.9797638 0.02023617
## 2        A.J. Burnett                  2011 0.9945918 0.00540825
## 3        A.J. Burnett                  2012 0.9899217 0.01007830
## 4        A.J. Burnett                  2013 0.9630357 0.03696435
## 5        A.J. Burnett                  2014 0.9481550 0.05184496
## 6        A.J. Burnett                  2015 0.9675416 0.03245842
##   pitchers_train$Top100
## 1                     0
## 2                     0
## 3                     0
## 4                     0
## 5                     0
## 6                     0
```

```r
  # Confusion matrix
  pitchers_cm_plr_trad = confusionMatrix(predict(pitchers_traditional_plr_model,
                                                 newdata = pitchers_test,
                                                 s = pitchers_traditional_plr_model$bestTune$lambda),
                                                 pitchers_test$Top100, positive='1')
  pitchers_cm_plr_trad$table
```

```
##           Reference
## Prediction    0    1
##          0 1085   48
##          1   17   67
```

```r
 # Selecting variables
  batters_advanced = batters_active[,c(16:29,32:45,48:51,63:72,75:76)]
  batters_advanced = cbind(batters[,c(1:6,191:193,190)],batters_advanced)

  # Dividing into test and train
  batters_train = batters_advanced[which(batters_advanced$playerid %in% batters_piselections),]
  batters_test = batters_advanced[which(batters_advanced$playerid %!in% batters_piselections),]

  # Removing variables not in model
  train_dv = batters_train[,c(1:9)]
  test_dv = batters_test[,c(1:9)]
```

```r
batters_train = batters_train[,-c(1:9)]
batters_test = batters_test[,-c(1:9)]

# Penalized logistic regression model
set.seed(2020)
cv_10 = trainControl(method = "cv", number = 10)

batters_advanced_plr_model <- train(form = Top100 ~ ., data = batters_train,
                            method = "glmnet",
                            family = "binomial",
                            trControl = cv_10,
                            tuneGrid = expand.grid(alpha = 1,
                                                   lambda = seq(0.001,0.1,by = 0.001)))

# Best lambda value
batters_advanced_plr_model$bestTune
```

```
##   alpha lambda
## 6     1  0.006
```

```r
# Coefficients at that lambda value
round(coef(batters_advanced_plr_model$finalModel, batters_advanced_plr_model$bestTune$lambda),3)
```

```
## 45 x 1 sparse Matrix of class "dgCMatrix"
##                                1
## (Intercept)                0.669
## BAbip_3yravg               .
## LDPercent_Bat_3yravg      -0.056
## GBPercent_Bat_3yravg       0.018
## FBPercent_Bat_3yravg       .
## HRPerFB_3yravg             0.021
## PullPercent_Bat_3yravg     .
## CentPercent_Bat_3yravg     .
## OppoPercent_Bat_3yravg     .
## SoftPercent_Bat_3yravg    -0.002
## MedPercent_Bat_3yravg     -0.021
## HardPercent_Bat_3yravg     0.010
## BBPerK_3yravg              .
## wOBA_3yravg                .
## OPSPlus_3yravg             .
## wRCPlus_3yravg             .
## BattingWins_BR_3yravg      .
## WAA_Bat_3yravg             0.533
## WAR_Pos_BR_3yravg          .
## oWAR_BR_3yravg             0.621
## WAR_Pos_FG_3yravg          0.111
## REW_Bat_3yravg             .
## WPA_Bat_3yravg             .
## pLI_Bat_3yravg            -4.048
## WPAPerLI_Bat_3yravg        .
## Clutch_Bat_3yravg          .
## OWnPercent_3yravg          .
## BattingWins_FG_3yravg      0.940
## oWAR_FG_3yravg             .
```

```
## UBR_3yravg             -0.015
## wGDP_3yravg            -0.020
## wSB_3yravg              0.107
## BsR_3yravg              .
## DRS_BR_3yravg           .
## Rgood_3yravg            .
## dWAR_BR_3yravg          .
## DRS_FG_3yravg           .
## dWAR_FG_3yravg          0.141
## AllStar_total           0.013
## GoldGlove_total         0.146
## SilverSlugger_total     0.315
## MVPRank_3yravg          .
## MVPVotePoints_3yravg    0.005
## ROYRank_3yravg          .
## ROYVotePoints_3yravg    0.006
```

```
  # Test data accuracy
  calc_accuracy_function(batters_test$Top100,
                         predict(batters_advanced_plr_model, newdata = batters_test,
                                 s = batters_advanced_plr_model$bestTune$lambda))
```

```
## [1] 0.8838269
```

```
  batters_train = cbind(train_dv[,1:9], batters_train[,1], batters_train[,2:45])
  colnames(batters_train)[10] = "Top100"

  # Dataset of predictions v actual
  batterscomp_plr_advanced = cbind(batters_train$Name, batters_train$Season,
                                   predict(batters_advanced_plr_model,
                                   newdata = batters_train,
                                   s = batters_advanced_plr_model$bestTune$lambda,
                                   type = "prob"), batters_train$Top100)
  head(batterscomp_plr_advanced)
```

```
##   batters_train$Name batters_train$Season         0          1
## 1         A.J. Ellis                 2013 0.8735693 0.12643071
## 2         A.J. Ellis                 2014 0.9451556 0.05484439
## 3         A.J. Ellis                 2015 0.9657759 0.03422411
## 4    A.J. Pierzynski                 2010 0.9875076 0.01249242
## 5    A.J. Pierzynski                 2011 0.9869686 0.01303135
## 6    A.J. Pierzynski                 2012 0.9580321 0.04196788
##   batters_train$Top100
## 1                    0
## 2                    0
## 3                    0
## 4                    0
## 5                    0
## 6                    1
```

```
  # Confusion matrix
  batters_cm_plr_adv = confusionMatrix(predict(batters_advanced_plr_model,
                                               newdata = batters_test,
                                               s = batters_advanced_plr_model$bestTune$lambda),
                                               batters_test$Top100, positive='1')
  batters_cm_plr_adv$table
```

```
##            Reference
## Prediction   0   1
##          0 638  61
##          1  41 138
```

```
library(glmnet)
 # Selecting variables
  pitchers_advanced = pitchers_active[,c(24:49,50:54,57:58,61:62)]
  pitchers_advanced = cbind(pitchers[,c(1:6,164:166,163)], pitchers_advanced)

  # Dividing into test and train
  pitchers_train = pitchers_advanced[which(pitchers_advanced$playerid %in% pitchers_piselections),]
  pitchers_test = pitchers_advanced[which(pitchers_advanced$playerid %!in% pitchers_piselections),]

  # Removing variables not in model
  train_dv = pitchers_train[,c(1:9)]
  test_dv = pitchers_test[,c(1:9)]
  pitchers_train = pitchers_train[,-c(1:9)]
  pitchers_test = pitchers_test[,-c(1:9)]

  # Penalized logistic regression model
  set.seed(2020)
  cv_10 = trainControl(method = "cv", number = 10)

  pitchers_advanced_plr_model <- train(form = Top100 ~ ., data = pitchers_train,
                               method = "glmnet",
                               family = "binomial",
                               trControl = cv_10,
                               tuneGrid = expand.grid(alpha = 1,
                                                      lambda = seq(0.001,0.1,by = 0.001)))

  # Best lambda value
  pitchers_advanced_plr_model$bestTune
```

```
##   alpha lambda
## 2     1  0.002
```

```
  # Coefficients at that lambda value
  round(coef(pitchers_advanced_plr_model$finalModel, pitchers_advanced_plr_model$bestTune$lambda),3)
```

```
## 36 x 1 sparse Matrix of class "dgCMatrix"
##                                  1
## (Intercept)                  3.614
## LOBPercent_3yravg            .
## LDPercent_Pitch_3yravg      -0.058
## GBPercent_Pitch_3yravg       .
## FBPercent_Pitch_3yravg       .
## SoftPercent_Pitch_3yravg     .
## MedPercent_Pitch_3yravg      .
## HardPercent_Pitch_3yravg     .
## BABIP_3yravg                 .
## ERAPlus_3yravg               .
## FIP_3yravg                  -0.304
## xFIP_3yravg                 -1.393
## SIERA_3yravg                 .
```

```
## WAR_Pitch_FG_3yravg         0.101
## gmLI_3yravg                 0.077
## WAA_Pitch_3yravg            .
## WAAadj_3yravg               0.879
## waaWLPercent_3yravg         .
## FullSeasonWLPercent_3yravg  .
## WAR_Pitch_BR_3yravg         .
## WPA_Pitch_3yravg            0.787
## REW_Pitch_3yravg            0.586
## pLI_Pitch_3yravg            .
## WPAPerLI_Pitch_3yravg       .
## Clutch_Pitch_3yravg         0.104
## SD_3yravg                   .
## MD_3yravg                  -0.231
## AllStar_total               0.116
## GoldGlove_total            -0.001
## SilverSlugger_total         0.004
## MVPRank_3yravg             -0.433
## MVPVotePoints_3yravg        .
## CYRank_3yravg               0.155
## CYVotePoints_3yravg         0.014
## ROYRank_3yravg              0.126
## ROYVotePoints_3yravg        0.007
```

```
  # Test data accuracy
  calc_accuracy_function(pitchers_test$Top100,
                         predict(pitchers_advanced_plr_model, newdata = pitchers_test,
                                 s = pitchers_advanced_plr_model$bestTune$lambda))
```

```
## [1] 0.9539852
```

```
  pitchers_train = cbind(train_dv[,1:9], pitchers_train[,1], pitchers_train[,2:36])
  colnames(pitchers_train)[10] = "Top100"

  # Dataset of predictions v actual
  pitcherscomp_plr_advanced = cbind(pitchers_train$Name, pitchers_train$Season,
                                    predict(pitchers_advanced_plr_model,
                                    newdata = pitchers_train,
                                    s = pitchers_advanced_plr_model$bestTune$lambda,
                                    type = "prob"), pitchers_train$Top100)
  head(pitcherscomp_plr_advanced)
```

```
##   pitchers_train$Name pitchers_train$Season         0           1
## 1        A.J. Burnett                  2010 0.9905722 0.009427836
## 2        A.J. Burnett                  2011 0.9982258 0.001774177
## 3        A.J. Burnett                  2012 0.9972094 0.002790577
## 4        A.J. Burnett                  2013 0.9790621 0.020937943
## 5        A.J. Burnett                  2014 0.9877541 0.012245892
## 6        A.J. Burnett                  2015 0.9812868 0.018713213
##   pitchers_train$Top100
## 1                     0
## 2                     0
## 3                     0
## 4                     0
## 5                     0
```

```
## 6                     0
```

```
  # Confusion matrix
  pitchers_cm_plr_adv = confusionMatrix(predict(pitchers_advanced_plr_model,
                                                newdata = pitchers_test,
                                                s = pitchers_advanced_plr_model$bestTune$lambda),
                                                pitchers_test$Top100, positive='1')
  pitchers_cm_plr_adv$table
```

```
##            Reference
## Prediction    0    1
##          0 1081   35
##          1   21   80
```

```
# Merging datasets
  batters_both = cbind(batters_traditional, batters_advanced)
  # Removing name, descriptive values and duplicates
  batters_both = batters_both[,-c(39:48,86:92)]

  # Dividing into test and train
  batters_train = batters_both[which(batters_both$playerid %in% batters_piselections),]
  batters_test = batters_both[which(batters_both$playerid %!in% batters_piselections),]

  # Removing variables not in model
  train_dv = batters_train[,c(1:9)]
  test_dv = batters_test[,c(1:9)]
  batters_train = batters_train[,-c(1:9)]
  batters_test = batters_test[,-c(1:9)]

  # Penalized logistic regression model
  set.seed(2020)
  cv_10 = trainControl(method = "cv", number = 10)

  batters_both_plr_model <- train(form = Top100 ~ ., data = batters_train,
                                  method = "glmnet",
                                  family = "binomial",
                                  trControl = cv_10,
                                  tuneGrid = expand.grid(alpha = 1,
                                                         lambda = seq(0.001,0.1,by = 0.001)))

  # Best lambda value
  batters_both_plr_model$bestTune
```

```
##   alpha lambda
## 8     1  0.008
```

```
  # Coefficients at that lambda value
  round(coef(batters_both_plr_model$finalModel, batters_both_plr_model$bestTune$lambda),3)
```

```
## 66 x 1 sparse Matrix of class "dgCMatrix"
##                               1
## (Intercept)             0.265
## H_Bat_3yravg            .
## BB_Bat_3yravg          -0.009
## SO_Bat_3yravg           0.000
## Doubles_3yravg          .
```

```
## Triples_3yravg          .
## HR_Bat_3yravg           0.002
## TB_3yravg               .
## RBI_3yravg              .
## BA_3yravg               .
## OBP_3yravg              .
## SLG_3yravg              .
## OPS_3yravg              .
## SB_3yravg               .
## CS_3yravg               .
## RCPerG_3yravg           0.018
## PO_3yravg               .
## A_3yravg                .
## E_3yravg                0.024
## DP_3yravg               .
## FldPercent_3yravg       .
## RFPer9_3yravg           .
## AllStar_total           0.026
## GoldGlove_total         0.137
## SilverSlugger_total     0.268
## MVPRank_3yravg          .
## MVPVotePoints_3yravg    0.004
## ROYRank_3yravg          .
## ROYVotePoints_3yravg    0.005
## BAbip_3yravg            .
## LDPercent_Bat_3yravg   -0.046
## GBPercent_Bat_3yravg    0.013
## FBPercent_Bat_3yravg    .
## HRPerFB_3yravg          0.017
## PullPercent_Bat_3yravg  .
## CentPercent_Bat_3yravg  .
## OppoPercent_Bat_3yravg  .
## SoftPercent_Bat_3yravg -0.001
## MedPercent_Bat_3yravg  -0.016
## HardPercent_Bat_3yravg  0.007
## BBPerK_3yravg           .
## wOBA_3yravg             .
## OPSPlus_3yravg          .
## wRCPlus_3yravg          .
## BattingWins_BR_3yravg   .
## WAA_Bat_3yravg          0.489
## WAR_Pos_BR_3yravg       .
## oWAR_BR_3yravg          0.478
## WAR_Pos_FG_3yravg       0.276
## REW_Bat_3yravg          .
## WPA_Bat_3yravg          .
## pLI_Bat_3yravg         -3.634
## WPAPerLI_Bat_3yravg     .
## Clutch_Bat_3yravg       .
## OWnPercent_3yravg       .
## BattingWins_FG_3yravg   0.964
## oWAR_FG_3yravg          .
## UBR_3yravg             -0.005
## wGDP_3yravg             .
```

```
## wSB_3yravg              0.068
## BsR_3yravg              .
## DRS_BR_3yravg           .
## Rgood_3yravg            .
## dWAR_BR_3yravg          .
## DRS_FG_3yravg           .
## dWAR_FG_3yravg          .
```

```
  # Test data accuracy
  calc_accuracy_function(batters_test$Top100,
                         predict(batters_both_plr_model, newdata = batters_test,
                                 s = batters_both_plr_model$bestTune$lambda))
```

```
## [1] 0.8826879
```

```
  batters_train = cbind(train_dv[,1:9], batters_train[,1], batters_train[,2:66])
  colnames(batters_train)[10] = "Top100"

  # Dataset of predictions v actual
  batterscomp_plr_both = cbind(batters_train$Name, batters_train$Season,
                                    predict(batters_both_plr_model,
                                    newdata = batters_train,
                                    s = batters_both_plr_model$bestTune$lambda,
                                    type = "prob"), batters_train$Top100)
  head(batterscomp_plr_both)
```

```
##   batters_train$Name batters_train$Season         0          1
## 1         A.J. Ellis                 2013 0.8905597 0.10944032
## 2         A.J. Ellis                 2014 0.9600852 0.03991476
## 3         A.J. Ellis                 2015 0.9751091 0.02489095
## 4    A.J. Pierzynski                 2010 0.9865358 0.01346417
## 5    A.J. Pierzynski                 2011 0.9859001 0.01409990
## 6    A.J. Pierzynski                 2012 0.9538396 0.04616040
##   batters_train$Top100
## 1                    0
## 2                    0
## 3                    0
## 4                    0
## 5                    0
## 6                    1
```

```
  # Confusion matrix
  batters_cm_plr_both = confusionMatrix(predict(batters_both_plr_model,
                                                newdata = batters_test,
                                                s = batters_both_plr_model$bestTune$lambda),
                                                batters_test$Top100, positive='1')
  batters_cm_plr_both$table
```

```
##           Reference
## Prediction   0   1
##          0 637  61
##          1  42 138
```

```
  # Combining dataset
  pitchers_both = cbind(pitchers_traditional, pitchers_advanced)
  # Removing unnecessary variables
  pitchers_both = pitchers_both[,-c(35:44,71:79)]
```

```r
# Dividing into test and train
pitchers_train = pitchers_both[which(pitchers_both$playerid %in% pitchers_piselections),]
pitchers_test = pitchers_both[which(pitchers_both$playerid %!in% pitchers_piselections),]

# Removing variables not in model
train_dv = pitchers_train[,c(1:9)]
test_dv = pitchers_test[,c(1:9)]
pitchers_train = pitchers_train[,-c(1:9)]
pitchers_test = pitchers_test[,-c(1:9)]

# Penalized logistic regression model
set.seed(2020)
cv_10 = trainControl(method = "cv", number = 10)

pitchers_both_plr_model <- train(form = Top100 ~ ., data = pitchers_train,
                                 method = "glmnet",
                                 family = "binomial",
                                 trControl = cv_10,
                                 tuneGrid = expand.grid(alpha = 1,
                                                        lambda = seq(0.001,0.1,by = 0.001)))

# Best lambda value
pitchers_both_plr_model$bestTune
```

```
##   alpha lambda
## 1     1  0.001
```

```r
# Coefficients at that lambda value
round(coef(pitchers_both_plr_model$finalModel, pitchers_both_plr_model$bestTune$lambda),3)
```

```
## 51 x 1 sparse Matrix of class "dgCMatrix"
##                                1
## (Intercept)                3.491
## W_3yravg                   0.030
## L_3yravg                   .
## CG_3yravg                  0.033
## SHO_3yravg                 0.353
## SV_3yravg                  0.064
## H_Pitch_3yravg             .
## R_Pitch_3yravg             .
## ER_3yravg                  .
## ERA_3yravg                 .
## WHIP_3yravg                .
## RSPer9_3yravg              .
## HR9_3yravg                -0.672
## BB9_3yravg                 0.440
## SO9_3yravg                 0.115
## RA9_3yravg                 .
## AllStar_total              .
## GoldGlove_total           -0.021
## SilverSlugger_total        .
## MVPRank_3yravg            -0.412
## MVPVotePoints_3yravg      -0.010
## CYRank_3yravg              0.143
```

```
## CYVotePoints_3yravg          0.015
## ROYRank_3yravg               0.145
## ROYVotePoints_3yravg         0.007
## LOBPercent_3yravg           -0.024
## LDPercent_Pitch_3yravg      -0.047
## GBPercent_Pitch_3yravg       .
## FBPercent_Pitch_3yravg       .
## SoftPercent_Pitch_3yravg     .
## MedPercent_Pitch_3yravg      .
## HardPercent_Pitch_3yravg     .
## BABIP_3yravg                 .
## ERAPlus_3yravg               .
## FIP_3yravg                   .
## xFIP_3yravg                 -1.640
## SIERA_3yravg                -0.120
## WAR_Pitch_FG_3yravg          0.003
## gmLI_3yravg                  0.422
## WAA_Pitch_3yravg             .
## WAAadj_3yravg                1.586
## waaWLPercent_3yravg          .
## FullSeasonWLPercent_3yravg   .
## WAR_Pitch_BR_3yravg          .
## WPA_Pitch_3yravg             0.558
## REW_Pitch_3yravg             1.048
## pLI_Pitch_3yravg             .
## WPAPerLI_Pitch_3yravg        .
## Clutch_Pitch_3yravg          0.285
## SD_3yravg                   -0.058
## MD_3yravg                   -0.299
```

```
  # Test data accuracy
  calc_accuracy_function(pitchers_test$Top100,
                         predict(pitchers_both_plr_model, newdata = pitchers_test,
                                 s = pitchers_both_plr_model$bestTune$lambda))
```

```
## [1] 0.9506984
```

```
  pitchers_train = cbind(train_dv[,1:9], pitchers_train[,1], pitchers_train[,2:51])
  colnames(pitchers_train)[10] = "Top100"

  # Dataset of predictions v actual
  pitcherscomp_plr_both = cbind(pitchers_train$Name, pitchers_train$Season,
                                predict(pitchers_both_plr_model,
                                newdata = pitchers_train,
                                s = pitchers_both_plr_model$bestTune$lambda,
                                type = "prob"), pitchers_train$Top100)
  head(pitcherscomp_plr_both)
```

```
##   pitchers_train$Name pitchers_train$Season         0           1
## 1        A.J. Burnett                  2010 0.9839259 0.016074115
## 2        A.J. Burnett                  2011 0.9980669 0.001933126
## 3        A.J. Burnett                  2012 0.9972141 0.002785873
## 4        A.J. Burnett                  2013 0.9755006 0.024499404
## 5        A.J. Burnett                  2014 0.9872433 0.012756732
## 6        A.J. Burnett                  2015 0.9832952 0.016704791
```

```
##   pitchers_train$Top100
## 1                     0
## 2                     0
## 3                     0
## 4                     0
## 5                     0
## 6                     0
```

```
  # Confusion matrix
  pitchers_cm_plr_both = confusionMatrix(predict(pitchers_both_plr_model,
                                                 newdata = pitchers_test,
                                                 s = pitchers_both_plr_model$bestTune$lambda),
                                                 pitchers_test$Top100, positive='1')
  pitchers_cm_plr_both$table
```

```
##            Reference
## Prediction    0    1
##          0 1080   38
##          1   22   77
```

PLR Results

```
cmlist = list(batters_cm_plr_trad$table, pitchers_cm_plr_trad$table,
              batters_cm_plr_adv$table, pitchers_cm_plr_adv$table,
              batters_cm_plr_both$table, pitchers_cm_plr_both$table)

get_confusion_matrix_function = function(cmlist){
  tablelist = list()
  for(i in 1:length(cmlist)){
    tablelist[[i]] = as.data.frame(cmlist[[i]])
    tablelist[[i]] = tablelist[[i]] %>%
  mutate(goodbad = ifelse(tablelist[[i]]$Prediction == tablelist[[i]]$Reference, "correct", "incorrect"]
  group_by(Reference) %>%
  mutate(prop = Freq/sum(Freq))
  }
  tablelist
}

cmlist = get_confusion_matrix_function(cmlist)
```

```
batters_cm_plr_trad_plot = ggplot(data = cmlist[[1]], mapping = aes(x = Reference, y = Prediction, fill
  geom_tile() +
  geom_text(aes(label = Freq), vjust = .5, fontface  = "bold", alpha = 1) +
  scale_fill_manual(values = c(correct = "green", incorrect = "red")) +
  theme_bw() +
  labs(fill = "Quality of Prediction", alpha = "Proportion") +
  ggtitle("CM for Traditional Variables - Batters") +
  theme(plot.title = element_text(hjust = 0.5))
```

```
pitchers_cm_plr_trad_plot = ggplot(data = cmlist[[2]], mapping = aes(x = Reference, y = Prediction, fil
  geom_tile() +
  geom_text(aes(label = Freq), vjust = .5, fontface  = "bold", alpha = 1) +
  scale_fill_manual(values = c(correct = "green", incorrect = "red")) +
  theme_bw() +
  labs(fill = "Quality of Prediction", alpha = "Proportion") +
```

```
  ggtitle("CM for Traditional Variables - Pitchers") +
  theme(plot.title = element_text(hjust = 0.5))
```

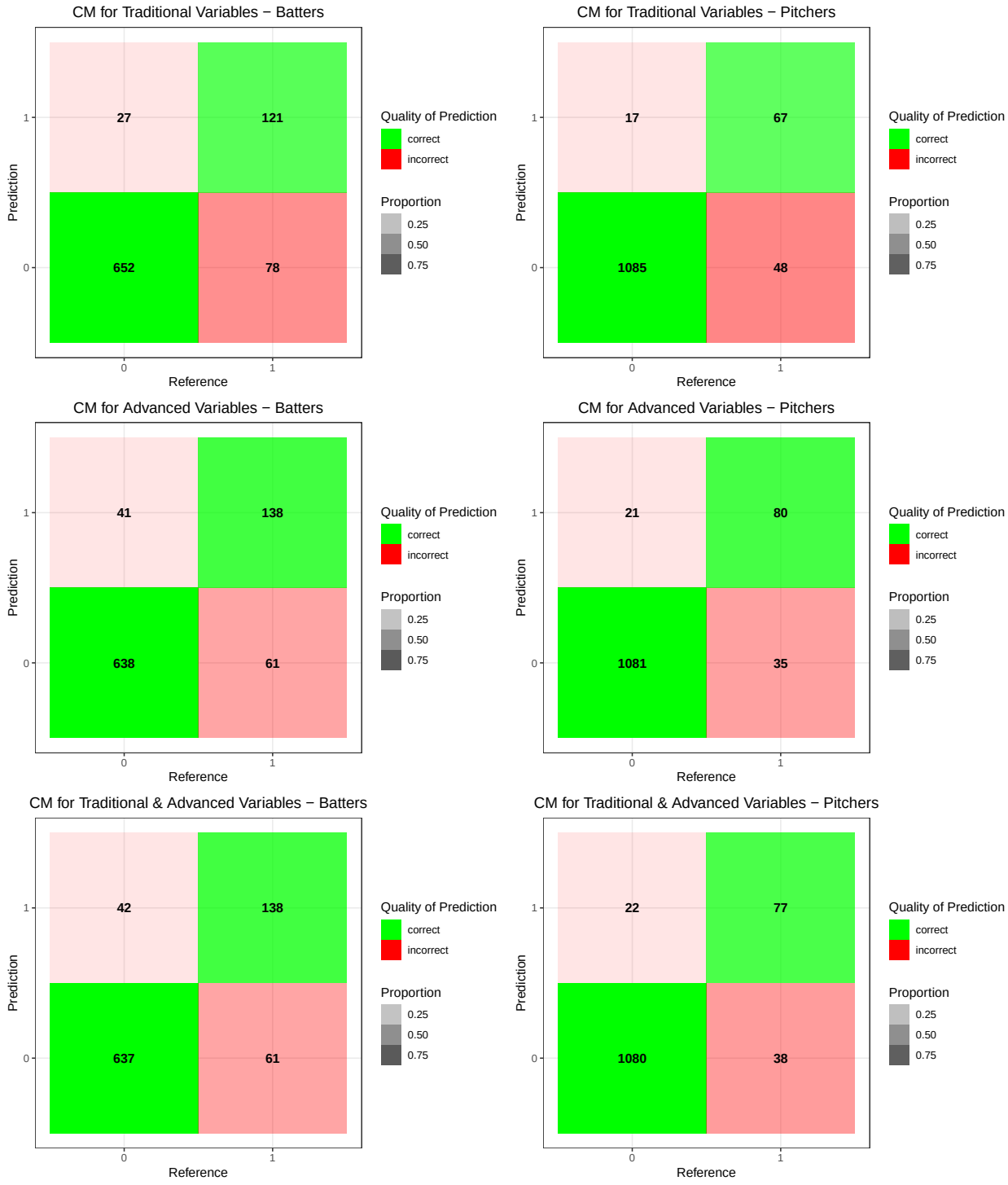
```
batters_cm_plr_adv_plot = ggplot(data = cmlist[[3]], mapping = aes(x = Reference, y = Prediction, fill =
  geom_tile() +
  geom_text(aes(label = Freq), vjust = .5, fontface  = "bold", alpha = 1) +
  scale_fill_manual(values = c(correct = "green", incorrect = "red")) +
  theme_bw() +
  labs(fill = "Quality of Prediction", alpha = "Proportion") +
  ggtitle("CM for Advanced Variables - Batters") +
  theme(plot.title = element_text(hjust = 0.5))
```

```
pitchers_cm_plr_adv_plot = ggplot(data = cmlist[[4]], mapping = aes(x = Reference, y = Prediction, fill
  geom_tile() +
  geom_text(aes(label = Freq), vjust = .5, fontface  = "bold", alpha = 1) +
  scale_fill_manual(values = c(correct = "green", incorrect = "red")) +
  theme_bw() +
  labs(fill = "Quality of Prediction", alpha = "Proportion") +
  ggtitle("CM for Advanced Variables - Pitchers") +
  theme(plot.title = element_text(hjust = 0.5))
```

```
batters_cm_plr_both_plot = ggplot(data = cmlist[[5]], mapping = aes(x = Reference, y = Prediction, fill
  geom_tile() +
  geom_text(aes(label = Freq), vjust = .5, fontface  = "bold", alpha = 1) +
  scale_fill_manual(values = c(correct = "green", incorrect = "red")) +
  theme_bw() +
  labs(fill = "Quality of Prediction", alpha = "Proportion") +
  ggtitle("CM for Traditional & Advanced Variables - Batters") +
  theme(plot.title = element_text(hjust = 0.5))
```

```
pitchers_cm_plr_both_plot = ggplot(data = cmlist[[6]], mapping = aes(x = Reference, y = Prediction, fil
  geom_tile() +
  geom_text(aes(label = Freq), vjust = .5, fontface  = "bold", alpha = 1) +
  scale_fill_manual(values = c(correct = "green", incorrect = "red")) +
  theme_bw() +
  labs(fill = "Quality of Prediction", alpha = "Proportion") +
  ggtitle("CM for Traditional & Advanced Variables - Pitchers") +
  theme(plot.title = element_text(hjust = 0.5))
```

```
library(cowplot)
plot_grid(batters_cm_plr_trad_plot,
pitchers_cm_plr_trad_plot,
batters_cm_plr_adv_plot,
pitchers_cm_plr_adv_plot,
batters_cm_plr_both_plot,
pitchers_cm_plr_both_plot, nrow = 3, ncol = 2)
```




```
tablelist =  list(batters_cm_plr_trad, batters_cm_plr_adv, batters_cm_plr_both,
                  pitchers_cm_plr_trad, pitchers_cm_plr_adv, pitchers_cm_plr_both)

cm_accuracy = rep(NA,6)
cm_sensitivity = rep(NA,6)
cm_specificity = rep(NA,6)
cm_pospredvalue = rep(NA,6)
```

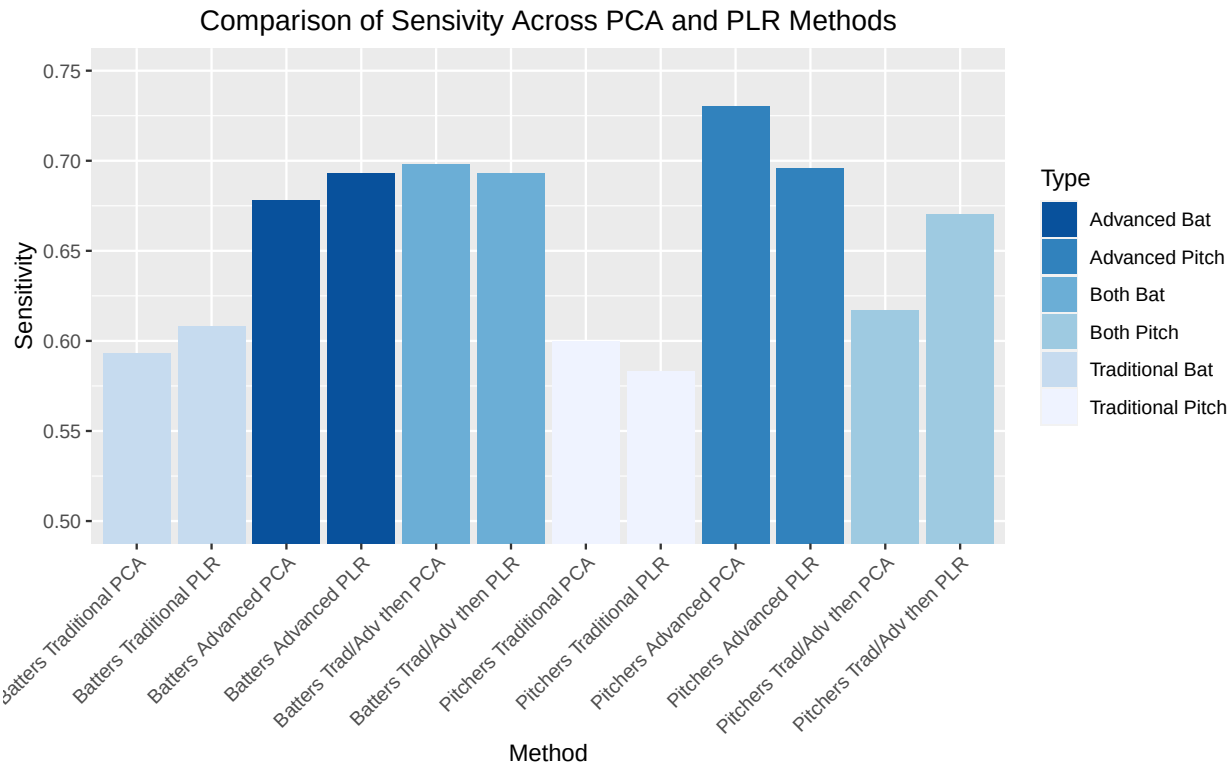
```
cm_negpredvalue = rep(NA,6)

for(i in 1:6){
  cm_accuracy[i] = round(tablelist[[i]]$overall['Accuracy'],3)
  cm_sensitivity[i] = round(tablelist[[i]]$byClass['Sensitivity'],3)
  cm_specificity[i] = round(tablelist[[i]]$byClass['Specificity'],3)
  cm_pospredvalue[i] = round(tablelist[[i]]$byClass['Pos Pred Value'],3)
  cm_negpredvalue[i] = round(tablelist[[i]]$byClass['Neg Pred Value'],3)
}

cm_names = c("Batters Traditional PLR", "Batters Advanced PLR",
             "Batters Trad/Adv then PLR", "Pitchers Traditional PLR", "Pitchers Advanced PLR", "Pitchers

cm_plr_table = as.data.frame(cbind(cm_names, cm_accuracy, cm_sensitivity, cm_specificity,cm_pospredvalu
colnames(cm_plr_table) = c("Method", "Accuracy", "Sensitivity", "Specificity", "Positive PV", "Negative
kable(cm_plr_table)
```

Method	Accuracy	Sensitivity	Specificity	Positive PV	Negative PV
Batters Traditional PLR	0.88	0.608	0.96	0.818	0.893
Batters Advanced PLR	0.884	0.693	0.94	0.771	0.913
Batters Trad/Adv then PLR	0.883	0.693	0.938	0.767	0.913
Pitchers Traditional PLR	0.947	0.583	0.985	0.798	0.958
Pitchers Advanced PLR	0.954	0.696	0.981	0.792	0.969
Pitchers Trad/Adv then PLR	0.951	0.67	0.98	0.778	0.966

```
pca_sensitivity = cm_table[c(1:2,4:6,8),c(1,3)]
plr_sensitivity = cm_plr_table[c(1:6),c(1,3)]

vc_comparison_table = rbind(pca_sensitivity, plr_sensitivity)
vc_comparison_table$Type = rep(c("Traditional Bat","Advanced Bat", "Both Bat", "Traditional Pitch", "Ad

vc_comparison_table$Method <- factor(vc_comparison_table$Method, levels = c("Batters Traditional PCA",

vc_comparison_table$Sensitivity = as.numeric(vc_comparison_table$Sensitivity)

library(scales)
```

```
##
## Attaching package: 'scales'

## The following object is masked from 'package:purrr':
##
##     discard

## The following object is masked from 'package:readr':
##
##     col_factor
```

```
ggplot(vc_comparison_table, aes(x = Method, y = Sensitivity, fill = Type)) +
  geom_bar(stat = "identity", position = position_dodge()) +
  theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  ggtitle("Comparison of Sensivity Across PCA and PLR Methods") +
  theme(plot.title = element_text(hjust = 0.5)) +
  scale_y_continuous(limits = c(0.5, 0.75),breaks = seq(0.5, 0.75, 0.05), oob=rescale_none) +
  scale_fill_brewer(palette = "Blues", direction = -1)
```


Comparison of Sensivity Across PCA and PLR Methods
Sensitivity
0.75
0.70
0.65
0.60
0.55
0.50
Batters Traditional PCA
Batters Traditional PLR
Batters Advanced PCA
Batters Advanced PLR
Batters Trad/Adv then PCA
Batters Trad/Adv then PLR
Pitchers Traditional PCA
Pitchers Traditional PLR
Pitchers Advanced PCA
Pitchers Advanced PLR
Pitchers Trad/Adv then PCA
Pitchers Trad/Adv then PLR
Method
Type
Advanced Bat
Advanced Pitch
Both Bat
Both Pitch
Traditional Bat
Traditional Pitch