

What Makes the Best Tennis Player?

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Loaded Packages

```
library(tidyverse)
library(olsrr)
library(cowplot)
library(car)
library(broom)
library(knitr)
library(arm)
library(tidyr)
library(pROC)
library(arm)
library(rlm)
```

Data Manipulation

```
atp <- read_csv("files/atp.csv")
atp2016 <- read_csv("files/atp2016.csv")
atp2015 <- read_csv("files/atp2015.csv")
atp2014 <- read_csv("files/atp2014.csv")
atp2013 <- read_csv("files/atp2013.csv")
atp2012 <- read_csv("files/atp2012.csv")
atp2011 <- read_csv("files/atp2011.csv")
atp2010 <- read_csv("files/atp2010.csv")

atp1 <- atp %>%
  filter(tourney_date < 20171113)

winners2016 <- atp2016 %>%
  filter(tourney_date < 20161114)

winners2015 <- atp2015 %>%
  filter(tourney_date < 20151115)

winners2014 <- atp2014 %>%
  filter(tourney_date < 20141109)

winners2013 <- atp2013 %>%
  filter(tourney_date < 20131104)

winners2012 <- atp2012 %>%
  filter(tourney_date < 20121105)
```

```

winners2011 <- atp2011 %>%
  filter(tourney_date < 20111114)

winners2010 <- atp2010 %>%
  filter(tourney_date < 20101121)

winners <- rbind(atp1, winners2016, winners2015, winners2014, winners2013,
                 winners2012, winners2011, winners2010)

winners_set <- winners %>%
  filter(best_of == 3,
         !is.na(w_ace),
         !is.na(w_df),
         !is.na(w_svpt),
         !is.na(w_1stIn),
         !is.na(w_1stWon),
         !is.na(w_2ndWon),
         !is.na(w_SvGms),
         !is.na(w_bpSaved),
         !is.na(w_bpFaced),
         surface!="None")

losers <- winners_set %>%
  mutate(seed = loser_seed,
         name = loser_name,
         hand = loser_hand,
         ht = loser_ht,
         age = loser_age,
         rank = loser_rank,
         rankpoints = loser_rank_points,
         ace = l_ace,
         df = l_df,
         svpt = l_svpt,
         firsstIn = l_1stIn,
         firsttWon = l_1stWon,
         secondndWon = l_2ndWon,
         SvGms = l_SvGms,
         bpSaved = l_bpSaved,
         bpFaced = l_bpFaced,
         minutes = minutes,
         status = 0
  )

winners <- winners_set %>%
  mutate(seed = winner_seed,
         name = winner_name,
         hand = winner_hand,
         ht = winner_ht,
         age = winner_age,
         rank = winner_rank,
         rankpoints = winner_rank_points,
         ace = w_ace,

```

```

df = w_df,
svpt = w_svpt,
firsstIn = w_1stIn,
firstrWon = w_1stWon,
secondndWon = w_2ndWon,
SvGms = w_SvGms,
bpSaved = w_bpSaved,
bpFaced = w_bpFaced,
minutes = minutes,
status = 1
)
tennis <- rbind(winners,losers)

tennis <- tennis %>%
  filter(!is.na(seed),
  !is.na(name),
  !is.na(hand),
  !is.na(ht),
  !is.na(age),
  !is.na(rank),
  !is.na(rankpoints),
  !is.na(ace),
  !is.na(df),
  !is.na(svpt),
  !is.na(firsstIn),
  !is.na(firstrWon),
  !is.na(secondndWon),
  !is.na(SvGms),
  !is.na(bpSaved),
  !is.na(bpFaced),
  !is.na(minutes),
  !is.na(status))

```

Data

Using data manipulation skills in R, we shaped the dataset to show each observation as the outcome of the match for the winner and the loser of each match from 2010-2017. Below, is a glimpse of our dataset.

```

glimpse(tennis)

## # Observations: 11,037
## # Variables: 66
## # tourney_id      <chr> "2017-M020", "2017-M020", "2017-M020", "201...
## # tourney_name    <chr> "Brisbane", "Brisbane", "Brisbane", "Brisba...
## # surface          <chr> "Hard", "Hard", "Hard", "Hard", "Ha...
## # draw_size        <int> 32, 32, 32, 32, 32, 32, 32, 32, 32, 32, ...
## # tourney_level    <chr> "A", "A", "A", "A", "A", "A", "A", "A"...
## # tourney_date     <int> 20170102, 20170102, 20170102, 20170102, 201...
## # match_num        <int> 300, 299, 298, 297, 296, 295, 294, 293, 292...
## # winner_id        <int> 105777, 105777, 105453, 105683, 105777, 105...
## # winner_seed      <int> 7, 7, 3, 1, 7, 3, 2, 1, 5, 4, 7, 3, 2, 5, 7...
## # winner_entry     <chr> NA, ...
## # winner_name       <chr> "Grigor Dimitrov", "Grigor Dimitrov", "Kei ...

```

```

## $ winner_hand          <chr> "R", "R", "R", "R", "R", "R", "R", "L"...
## $ winner_ht            <int> 188, 188, 178, 196, 188, 178, 183, 196, 185...
## $ winner_ioc           <chr> "BUL", "BUL", "JPN", "CAN", "BUL", "JPN", "...
## $ winner_age           <dbl> 25.63450, 25.63450, 27.01164, 26.01780, 25....
## $ winner_rank           <int> 17, 17, 5, 3, 17, 5, 4, 3, 9, 8, 17, 5, 4, ...
## $ winner_rank_points    <int> 2035, 2035, 4905, 5450, 2035, 4905, 5315, 5...
## $ loser_id              <int> 105453, 105683, 104527, 104745, 106233, 111...
## $ loser_seed             <int> 3, 1, 2, 5, 4, NA, NA, NA, NA, NA, NA, ...
## $ loser_entry            <chr> NA, NA, NA, NA, "WC", NA, NA, NA, "WC",...
## $ loser_name             <chr> "Kei Nishikori", "Milos Raonic", "Stanislas...
## $ loser_hand             <chr> "R", "R", "R", "L", "R", "R", "R", "R", "L"...
## $ loser_ht               <int> 178, 196, 183, 185, 185, NA, NA, 170, 190, ...
## $ loser_ioc              <chr> "JPN", "CAN", "SUI", "ESP", "AUT", "AUS", "...
## $ loser_age              <dbl> 27.01164, 26.01780, 31.76728, 30.58453, 23....
## $ loser_rank             <int> 5, 3, 4, 9, 8, 79, 45, 52, 51, 180, 39, 105...
## $ loser_rank_points      <int> 4905, 5450, 5315, 3300, 3415, 689, 1001, 86...
## $ score                 <chr> "6-2 2-6 6-3", "7-6(7) 6-2", "7-6(3) 6-3", ...
## $ best_of                <int> 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3...
## $ round                  <chr> "F", "SF", "SF", "QF", "QF", "QF", "QF", "R...
## $ minutes                <int> 108, 87, 101, 140, 124, 61, 156, 69, 55, 89...
## $ w_ace                  <int> 7, 4, 1, 23, 3, 3, 11, 12, 1, 11, 8, 3, 7, ...
## $ w_df                   <int> 2, 1, 1, 3, 3, 0, 3, 1, 2, 1, 0, 3, 2, 1, 0...
## $ w_svpt                 <int> 77, 58, 77, 97, 94, 34, 119, 53, 38, 65, 46...
## $ w_1stIn                <int> 52, 36, 56, 62, 52, 19, 67, 40, 18, 44, 27, ...
## $ w_1stWon               <int> 41, 27, 37, 50, 42, 18, 47, 30, 15, 36, 25, ...
## $ w_2ndWon               <int> 12, 18, 14, 16, 23, 10, 28, 7, 15, 15, 12, ...
## $ w_SvGms                <int> 13, 10, 11, 15, 14, 7, 16, 9, 7, 11, 9, 15, ...
## $ w_bpSaved              <int> 5, 0, 4, 6, 13, 0, 11, 2, 2, 4, 3, 4, 0, 2, ...
## $ w_bpFaced              <int> 7, 0, 5, 7, 14, 0, 13, 3, 2, 4, 3, 8, 1, 3, ...
## $ l_ace                  <int> 4, 4, 9, 4, 6, 1, 2, 0, 2, 11, 4, 6, 5, 2, ...
## $ l_df                   <int> 0, 3, 2, 0, 5, 2, 2, 1, 2, 1, 3, 4, 7, 2, 3...
## $ l_svpt                 <int> 69, 61, 61, 84, 82, 47, 97, 44, 38, 58, 52, ...
## $ l_1stIn                <int> 49, 28, 37, 61, 37, 28, 65, 29, 25, 35, 37, ...
## $ l_1stWon               <int> 36, 24, 27, 39, 29, 15, 52, 17, 13, 34, 27, ...
## $ l_2ndWon               <int> 9, 16, 10, 14, 24, 5, 11, 6, 3, 9, 4, 20, 8...
## $ l_SvGms                <int> 12, 10, 10, 14, 14, 7, 16, 8, 7, 10, 9, 14, ...
## $ l_bpSaved              <int> 2, 2, 0, 2, 4, 3, 6, 2, 3, 3, 0, 8, 3, 0, 4...
## $ l_bpFaced              <int> 5, 4, 2, 4, 7, 8, 10, 6, 8, 4, 3, 13, 5, 4, ...
## $ seed                   <int> 7, 7, 3, 1, 7, 3, 2, 1, 5, 4, 7, 3, 2, 5, 7...
## $ name                   <chr> "Grigor Dimitrov", "Grigor Dimitrov", "Kei ...
## $ hand                   <chr> "R", "R", "R", "R", "R", "R", "R", "L"...
## $ ht                      <int> 188, 188, 178, 196, 188, 178, 183, 196, 185...
## $ age                     <dbl> 25.63450, 25.63450, 27.01164, 26.01780, 25....
## $ rank                    <int> 17, 17, 5, 3, 17, 5, 4, 3, 9, 8, 17, 5, 4, ...
## $ rankpoints             <int> 2035, 2035, 4905, 5450, 2035, 4905, 5315, 5...
## $ ace                     <int> 7, 4, 1, 23, 3, 3, 11, 12, 1, 11, 8, 3, 7, ...
## $ df                      <int> 2, 1, 1, 3, 3, 0, 3, 1, 2, 1, 0, 3, 2, 1, 0...
## $ svpt                    <int> 77, 58, 77, 97, 94, 34, 119, 53, 38, 65, 46...
## $ firsstIn                <int> 52, 36, 56, 62, 52, 19, 67, 40, 18, 44, 27, ...
## $ firsttWon              <int> 41, 27, 37, 50, 42, 18, 47, 30, 15, 36, 25, ...
## $ secondndWon             <int> 12, 18, 14, 16, 23, 10, 28, 7, 15, 15, 12, ...
## $ SvGms                  <int> 13, 10, 11, 15, 14, 7, 16, 9, 7, 11, 9, 15, ...
## $ bpSaved                 <int> 5, 0, 4, 6, 13, 0, 11, 2, 2, 4, 3, 4, 0, 2, ...
## $ bpFaced                 <int> 7, 0, 5, 7, 14, 0, 13, 3, 2, 4, 3, 8, 1, 3, ...

```

```
## $ status <dbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1...
```

Because we have 11,037 observations, we will randomly select observations to be included in a smaller dataset so that we can effectively examine exploratory data analysis. Below, is our code on how we randomly selected the observations in our new dataset.

```
set.seed(1234)
ten <- tennis %>% sample_n(1000)
```

Here is what our new dataset looks like:

```
glimpse(ten)
```

```
## Observations: 1,000
## Variables: 66
## $ tourney_id <chr> "2016-M021", "2010-314", "2010-404", "2010-...
## $ tourney_name <chr> "Madrid Masters", "Gstaad", "Indian Wells M...
## $ surface <chr> "Clay", "Clay", "Hard", "Grass", "Clay", "H...
## $ draw_size <int> 64, 32, 96, 32, 56, 32, 32, 28, 32, 96, 32, ...
## $ tourney_level <chr> "M", "A", "M", "A", "A", "A", "A", "A", "A"...
## $ tourney_date <int> 20160502, 20100725, 20100311, 20100705, 201...
## $ match_num <int> 283, 29, 33, 27, 26, 293, 293, 3, 295, 37, ...
## $ winner_id <int> 105683, 104755, 103819, 103888, 104857, 106...
## $ winner_seed <int> 11, 7, 1, 5, NA, NA, 1, 7, 4, 11, 4, 16, 8, ...
## $ winner_entry <chr> NA, NA, NA, NA, "Q", "Q", NA, NA, NA, NA, N...
## $ winner_name <chr> "Milos Raonic", "Richard Gasquet", "Roger F...
## $ winner_hand <chr> "R", "R", "R", "R", "R", "R", "R", "R"...
## $ winner_ht <int> 196, 185, 185, 188, 193, NA, 178, 183, 198, ...
## $ winner_ioc <chr> "CAN", "FRA", "SUI", "USA", "COL", "SVK", "...
## $ winner_age <dbl> 25.34702, 24.10404, 28.58042, 28.56947, 25....
## $ winner_rank <int> 10, 47, 1, 79, 246, 117, 5, 41, 12, 12, 12, ...
## $ winner_rank_points <int> 2740, 930, 11350, 651, 195, 501, 4625, 1010...
## $ loser_id <int> 105238, 103393, 103812, 104433, 104665, 105...
## $ loser_seed <int> NA, NA, NA, NA, 16, 1, NA, NA, 7, NA, 8, NA...
## $ loser_entry <chr> NA, "Q", NA, NA, NA, NA, NA, NA, "Q", N...
## $ loser_name <chr> "Alexandr Dolgopolov", "Yuri Schukin", "Vic...
## $ loser_hand <chr> "R", "R", "R", "R", "R", "R", "R", "R"...
## $ loser_ht <int> 180, 188, 198, 185, 180, 198, 170, 188, 183...
## $ loser_ioc <chr> "UKR", "KAZ", "ROU", "CAN", "ESP", "CRO", "...
## $ loser_age <dbl> 27.48255, 31.08282, 28.62971, 25.77139, 26....
## $ loser_rank <int> 29, 147, 43, 336, 38, 6, 50, 122, 19, 89, 2...
## $ loser_rank_points <int> 1330, 344, 905, 115, 1070, 3650, 890, 500, ...
## $ score <chr> "6-4 6-7(3) 6-2", "6-3 6-4", "6-3 6-7(5) 6-...
## $ best_of <int> 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3...
## $ round <chr> "R32", "SF", "R64", "QF", "R32", "R16", "R1...
## $ minutes <int> 121, 89, 117, 134, 170, 168, 124, 120, 132, ...
## $ w_ace <int> 17, 6, 10, 7, 9, 8, 3, 1, 19, 9, 22, 6, 7, ...
## $ w_df <int> 2, 6, 2, 2, 1, 2, 0, 1, 1, 3, 4, 0, 1, 3, 1...
## $ w_svpt <int> 95, 72, 95, 91, 123, 130, 92, 82, 86, 57, 8...
## $ w_1stIn <int> 70, 42, 52, 45, 76, 83, 61, 62, 58, 39, 54, ...
## $ w_1stWon <int> 56, 33, 41, 38, 49, 55, 43, 39, 51, 32, 42, ...
## $ w_2ndWon <int> 14, 16, 27, 26, 25, 30, 13, 12, 18, 10, 21, ...
## $ w_SvGms <int> 15, 10, 15, 16, 17, 18, 14, 12, 15, 10, 15, ...
## $ w_bpSaved <int> 4, 2, 6, 2, 10, 9, 8, 5, 0, 2, 4, 1, 1, 0, ...
## $ w_bpFaced <int> 4, 2, 7, 5, 15, 11, 11, 7, 0, 3, 5, 1, 4, 1...
## $ l_ace <int> 7, 2, 1, 6, 1, 18, 2, 0, 2, 1, 13, 5, 17, 5...
```

```

## $ l_df          <int> 1, 1, 1, 5, 5, 2, 0, 5, 1, 4, 7, 2, 5, 5, 0...
## $ l_svpt        <int> 95, 57, 101, 98, 103, 113, 81, 82, 108, 69, ...
## $ l_1stIn       <int> 56, 32, 77, 54, 64, 69, 56, 53, 82, 49, 44, ...
## $ l_1stWon      <int> 39, 25, 48, 42, 47, 53, 35, 34, 51, 33, 32, ...
## $ l_2ndWon      <int> 24, 12, 10, 15, 17, 26, 8, 13, 16, 8, 30, 6...
## $ l_SvGms        <int> 15, 9, 13, 16, 17, 18, 14, 12, 16, 10, 14, ...
## $ l_bpSaved      <int> 3, 4, 8, 1, 3, 3, 4, 9, 4, 8, 8, 2, 6, 6, 7...
## $ l_bpFaced      <int> 6, 6, 12, 6, 8, 5, 10, 13, 7, 11, 12, 6, 8, ...
## $ seed           <int> 11, 7, 1, 5, 16, 1, 1, 7, 7, 11, 8, 16, 8, ...
## $ name           <chr> "Milos Raonic", "Richard Gasquet", "Roger F...
## $ hand           <chr> "R", "R", "R", "R", "R", "R", "R", "R"...
## $ ht             <int> 196, 185, 185, 188, 180, 198, 178, 183, 183...
## $ age            <dbl> 25.34702, 24.10404, 28.58042, 28.56947, 26....
## $ rank           <int> 10, 47, 1, 79, 38, 6, 5, 41, 19, 12, 22, 24...
## $ rankpoints     <int> 2740, 930, 11350, 651, 1070, 3650, 4625, 10...
## $ ace            <int> 17, 6, 10, 7, 1, 18, 3, 1, 2, 9, 13, 6, 7, ...
## $ df              <int> 2, 6, 2, 2, 5, 2, 0, 1, 1, 3, 7, 0, 1, 5, 1...
## $ svpt           <int> 95, 72, 95, 91, 103, 113, 92, 82, 108, 57, ...
## $ firsstIn       <int> 70, 42, 52, 45, 64, 69, 61, 62, 82, 39, 44, ...
## $ firsttWon      <int> 56, 33, 41, 38, 47, 53, 43, 39, 51, 32, 32, ...
## $ secondndWon    <int> 14, 16, 27, 26, 17, 26, 13, 12, 16, 10, 30, ...
## $ SvGms          <int> 15, 10, 15, 16, 17, 18, 14, 12, 16, 10, 14, ...
## $ bpSaved         <int> 4, 2, 6, 2, 3, 3, 8, 5, 4, 2, 8, 1, 1, 6, 1...
## $ bpFaced         <int> 4, 2, 7, 5, 8, 5, 11, 7, 7, 3, 12, 1, 4, 10...
## $ status          <dbl> 1, 1, 1, 1, 0, 0, 1, 1, 0, 1, 0, 1, 1, 0, 1...

```

Exploratory Data Analysis

To begin our exploratory data analysis, we will examine a matrix plot of the variables in our dataset to consider multicollinearity and large leverage of certain observations.

Matrix Plot

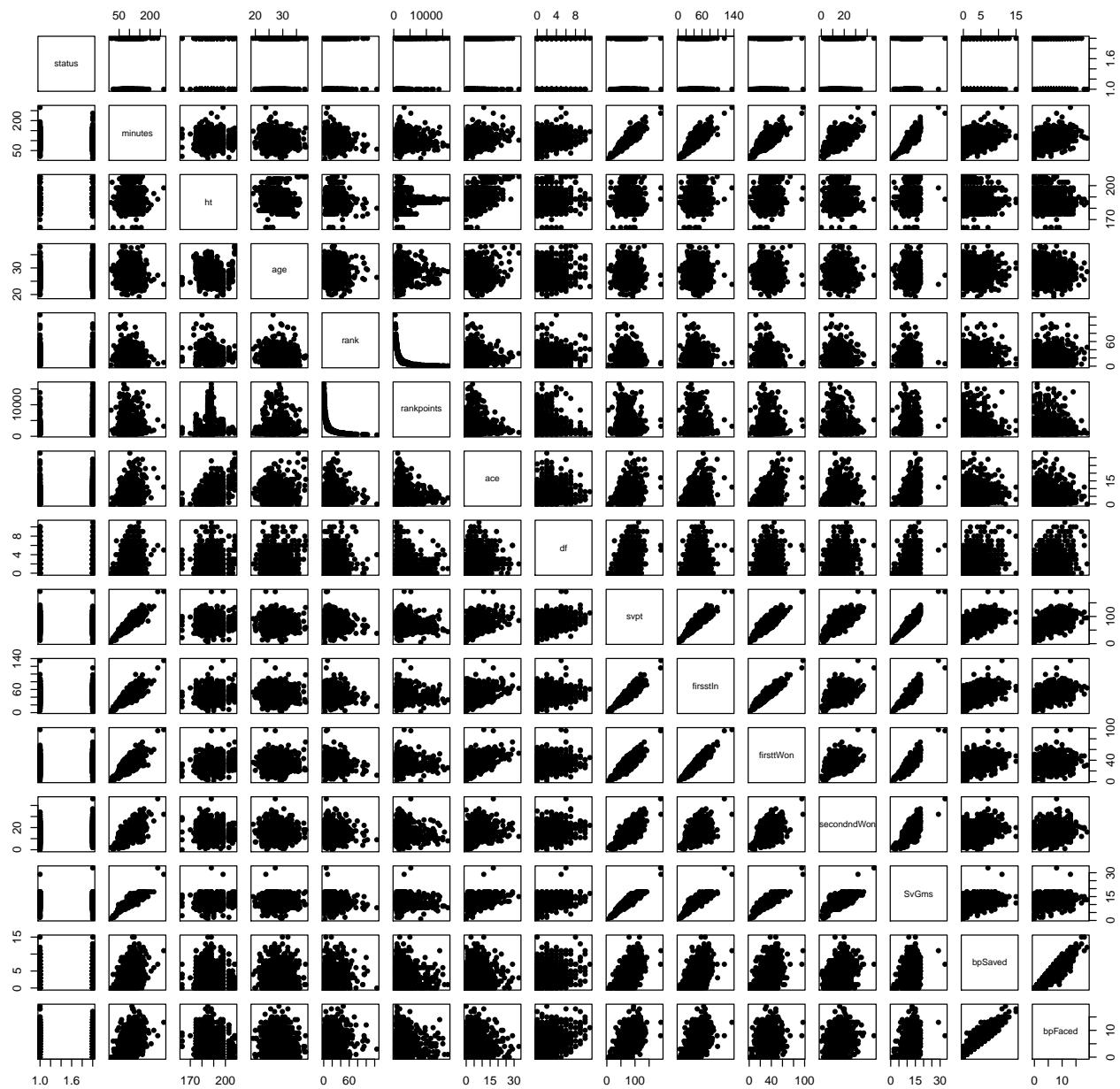
```

ten <- ten %>%
  mutate(status = as.factor(status))

pairs(status ~ minutes + ht + age + rank + rankpoints + ace +
  df + svpt + firsstIn + firsttWon + secondndWon +
  SvGms + bpSaved + bpFaced, data=ten, pch = 16,
  main = "Matrix of scatterplots for Tournament Wins and Variables")

```

Matrix of scatterplots for Tournament Wins and Variables



Looking at the matrix plot, we will already consider removing the following variables because of multicollinearity: svpt, firsstIn, firsttWon, secondndWon, SvGms, and bpFaced.

We will now look at box plots of the numeric variables we will include in our full model:

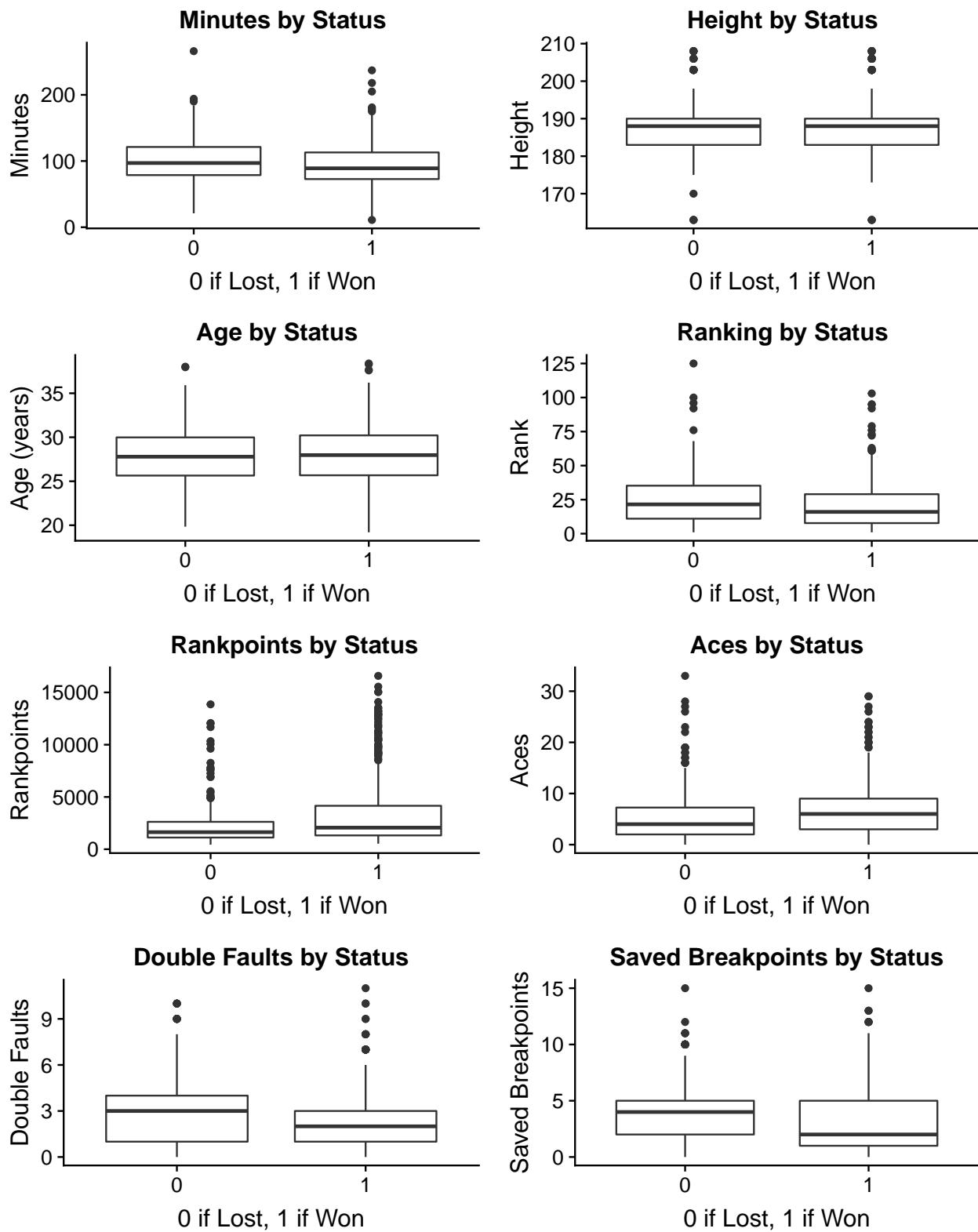
```
p1 <- ggplot(data=ten,aes(x=status,y=minutes, group=status)) +
  geom_boxplot() +
  labs(title="Minutes by Status",
      x = "0 if Lost, 1 if Won",
      y = "Minutes")
p2 <- ggplot(data=ten,aes(x=status,y=ht, group=status)) +
  geom_boxplot() +
  labs(title="Height by Status",
      x = "0 if Lost, 1 if Won",
      y = "Height")
```

```

p3 <- ggplot(data=ten,aes(x=status,y=age, group=status)) +
  geom_boxplot() +
  labs(title="Age by Status",
       x = "0 if Lost, 1 if Won",
       y = "Age (years)")
p4 <- ggplot(data=ten,aes(x=status,y=rank, group=status)) +
  geom_boxplot() +
  labs(title="Ranking by Status",
       x = "0 if Lost, 1 if Won",
       y = "Rank")
p5 <- ggplot(data=ten,aes(x=status,y=rankpoints, group=status)) +
  geom_boxplot() +
  labs(title="Rankpoints by Status",
       x = "0 if Lost, 1 if Won",
       y = "Rankpoints")
p6 <- ggplot(data=ten,aes(x=status,y=ace, group=status)) +
  geom_boxplot() +
  labs(title="Aces by Status",
       x = "0 if Lost, 1 if Won",
       y = "Aces")
p7 <- ggplot(data=ten,aes(x=status,y=df, group=status)) +
  geom_boxplot() +
  labs(title="Double Faults by Status",
       x = "0 if Lost, 1 if Won",
       y = "Double Faults")
p8 <- ggplot(data=ten,aes(x=status,y=bpSaved, group=status)) +
  geom_boxplot() +
  labs(title="Saved Breakpoints by Status",
       x = "0 if Lost, 1 if Won",
       y = "Saved Breakpoints")

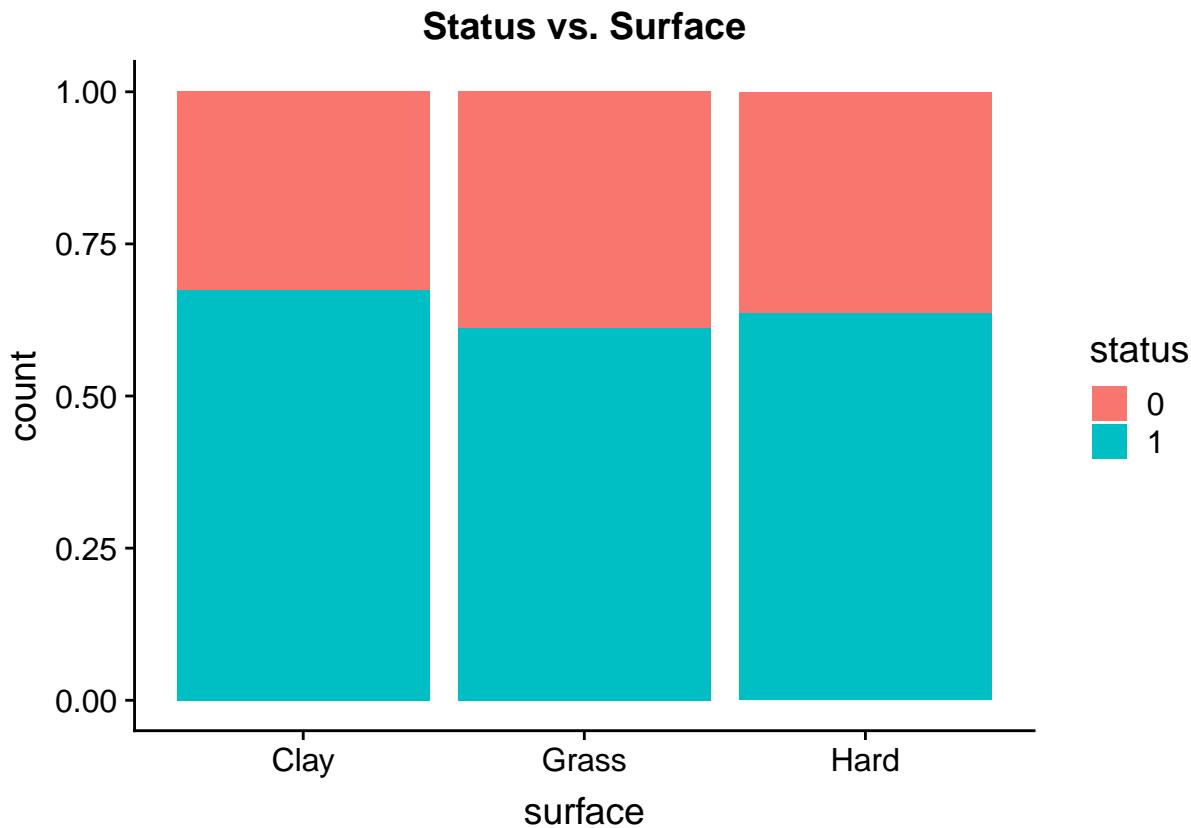
plot_grid(p1,p2,p3,p4,p5,
          p6,p7,p8,ncol=2)

```



And we will include a stacked bar graph for the variable `surface`.

```
ggplot(data=ten,aes(x=surface, fill = status)) + geom_bar(position = "fill") +
  labs(title="Status vs. Surface")
```



In looking at all of these observations, it seems like the medians of the numeric distributions do not seem to differ that much by status of winning or losing. The same can be said about the proportions of winning and losing matches against all three surfaces. In creating our model, it could be difficult to see which variables could be helpful in differentiating between whether a player will win a match or not. But, we hope to see that a combination of these variables will be helpful in determining a model that best predicts the percentage of winning a match.

Logistic Regression Model

To begin our regression models, we will use all of the variables we deemed important from our exploratory data analysis.

```
full_model <- glm(status ~ minutes + ht + age + rank +
                     rankpoints + ace + df + bpSaved + surface,
                     family=binomial, data=ten)
kable(tidy(full_model), format="markdown", digits = 3)
```

term	estimate	std.error	statistic	p.value
(Intercept)	5.060	2.219	2.280	0.023
minutes	-0.007	0.003	-2.607	0.009
ht	-0.024	0.011	-2.278	0.023
age	0.024	0.022	1.085	0.278
rank	-0.002	0.006	-0.279	0.780
rankpoints	0.000	0.000	3.963	0.000
ace	0.108	0.019	5.674	0.000
df	-0.140	0.037	-3.830	0.000

term	estimate	std.error	statistic	p.value
bpSaved	-0.077	0.029	-2.650	0.008
surfaceGrass	-0.580	0.280	-2.076	0.038
surfaceHard	-0.494	0.165	-3.000	0.003

```

full_w_interactions <- glm(status ~ minutes + ht + age + rank +
                           rankpoints + ace + df + bpSaved + surface + surface * minutes +
                           surface * ht + surface * age + surface * rank + surface * rankpoints +
                           surface * ace + surface * df + surface * bpSaved,
                           family=binomial,data=ten)

tidy(anova(full_model, full_w_interactions, test = "Chisq"))

## Warning in tidy.anova(anova(full_model, full_w_interactions, test =
## "Chisq")): The following column names in ANOVA output were not recognized
## or transformed: Resid..Df, Resid..Dev, Deviance

## Warning: Unknown or uninitialized column: 'term'.

## # A tibble: 2 x 5
##   Resid..Df Resid..Dev   df Deviance p.value
## *     <dbl>      <dbl> <dbl>     <dbl>    <dbl>
## 1      989       1176.    NA       NA     NA
## 2      973       1149.    16      26.6  0.0457

model.selected.interactions <- step(full_w_interactions,direction="backward")

## Start:  AIC=1202.97
## status ~ minutes + ht + age + rank + rankpoints + ace + df +
##         bpSaved + surface + surface * minutes + surface * ht + surface *
##         age + surface * rank + surface * rankpoints + surface * ace +
##         surface * df + surface * bpSaved
##
##                               Df Deviance   AIC
## - rank:surface          2   1149.4 1199.4
## - age:surface            2   1150.3 1200.3
## - bpSaved:surface        2   1150.5 1200.5
## - rankpoints:surface     2   1150.5 1200.5
## - minutes:surface        2   1150.6 1200.6
## <none>                  1149.0 1203.0
## - df:surface             2   1154.7 1204.7
## - ht:surface              2   1154.7 1204.7
## - ace:surface            2   1156.9 1206.9
##
## Step:  AIC=1199.39
## status ~ minutes + ht + age + rank + rankpoints + ace + df +
##         bpSaved + surface + minutes:surface + ht:surface + age:surface +
##         rankpoints:surface + ace:surface + df:surface + bpSaved:surface
##
##                               Df Deviance   AIC
## - bpSaved:surface        2   1150.7 1196.7
## - age:surface            2   1150.8 1196.8
## - minutes:surface        2   1150.9 1196.9
## - rankpoints:surface     2   1151.1 1197.1
## - rank                     1   1149.6 1197.6

```

```

## <none>          1149.4 1199.4
## - ht:surface    2   1154.8 1200.8
## - df:surface    2   1154.8 1200.8
## - ace:surface   2   1157.6 1203.6
##
## Step: AIC=1196.71
## status ~ minutes + ht + age + rank + rankpoints + ace + df +
##      bpSaved + surface + minutes:surface + ht:surface + age:surface +
##      rankpoints:surface + ace:surface + df:surface
##
##           Df Deviance   AIC
## - minutes:surface 2   1151.6 1193.6
## - age:surface      2   1151.9 1193.9
## - rankpoints:surface 2   1152.4 1194.4
## - rank             1   1150.9 1194.9
## <none>            1150.7 1196.7
## - ht:surface       2   1156.4 1198.4
## - ace:surface      2   1158.1 1200.1
## - bpSaved          1   1156.8 1200.8
## - df:surface       2   1159.6 1201.6
##
## Step: AIC=1193.59
## status ~ minutes + ht + age + rank + rankpoints + ace + df +
##      bpSaved + surface + ht:surface + age:surface + rankpoints:surface +
##      ace:surface + df:surface
##
##           Df Deviance   AIC
## - age:surface      2   1153.0 1191.0
## - rankpoints:surface 2   1153.7 1191.7
## - rank             1   1151.8 1191.8
## <none>            1151.6 1193.6
## - ht:surface       2   1156.8 1194.8
## - ace:surface      2   1158.4 1196.4
## - bpSaved          1   1157.6 1197.6
## - df:surface       2   1160.4 1198.4
## - minutes          1   1159.3 1199.3
##
## Step: AIC=1190.98
## status ~ minutes + ht + age + rank + rankpoints + ace + df +
##      bpSaved + surface + ht:surface + rankpoints:surface + ace:surface +
##      df:surface
##
##           Df Deviance   AIC
## - rankpoints:surface 2   1154.9 1188.9
## - rank             1   1153.2 1189.2
## - age              1   1153.5 1189.5
## <none>            1153.0 1191.0
## - ht:surface       2   1158.7 1192.7
## - ace:surface      2   1160.6 1194.6
## - bpSaved          1   1159.2 1195.2
## - df:surface       2   1162.2 1196.2
## - minutes          1   1160.8 1196.8
##
## Step: AIC=1188.92

```

```

## status ~ minutes + ht + age + rank + rankpoints + ace + df +
##      bpSaved + surface + ht:surface + ace:surface + df:surface
##
##          Df Deviance    AIC
## - rank      1  1155.1 1187.1
## - age       1  1155.5 1187.5
## <none>        1154.9 1188.9
## - ht:surface 2  1160.6 1190.6
## - ace:surface 2  1162.5 1192.5
## - bpSaved    1  1161.3 1193.3
## - minutes    1  1162.9 1194.9
## - df:surface 2  1164.9 1194.9
## - rankpoints 1  1173.8 1205.8
##
## Step:  AIC=1187.07
## status ~ minutes + ht + age + rankpoints + ace + df + bpSaved +
##      surface + ht:surface + ace:surface + df:surface
##
##          Df Deviance    AIC
## - age       1  1155.6 1185.6
## <none>        1155.1 1187.1
## - ht:surface 2  1160.7 1188.7
## - ace:surface 2  1162.7 1190.7
## - bpSaved    1  1161.7 1191.7
## - minutes    1  1162.9 1192.9
## - df:surface 2  1165.1 1193.1
## - rankpoints 1  1193.0 1223.0
##
## Step:  AIC=1185.62
## status ~ minutes + ht + rankpoints + ace + df + bpSaved + surface +
##      ht:surface + ace:surface + df:surface
##
##          Df Deviance    AIC
## <none>        1155.6 1185.6
## - ht:surface  2  1161.4 1187.4
## - ace:surface 2  1163.5 1189.5
## - bpSaved     1  1162.1 1190.1
## - minutes     1  1163.8 1191.8
## - df:surface   2  1165.8 1191.8
## - rankpoints   1  1193.6 1221.6

```

Linear Regression Assumptions

```

final.base.model <- model.selected.interactions
kable(tidy(final.base.model), format = "markdown", digits = 3)

```

term	estimate	std.error	statistic	p.value
(Intercept)	10.392	3.518	2.954	0.003
minutes	-0.008	0.003	-2.844	0.004
ht	-0.048	0.019	-2.547	0.011
rankpoints	0.000	0.000	5.441	0.000

term	estimate	std.error	statistic	p.value
ace	0.110	0.040	2.764	0.006
df	-0.243	0.070	-3.474	0.001
bpSaved	-0.075	0.029	-2.548	0.011
surfaceGrass	5.285	8.299	0.637	0.524
surfaceHard	-8.048	4.294	-1.874	0.061
ht:surfaceGrass	-0.043	0.045	-0.940	0.347
ht:surfaceHard	0.040	0.023	1.710	0.087
ace:surfaceGrass	0.164	0.080	2.048	0.041
ace:surfaceHard	-0.021	0.045	-0.469	0.639
df:surfaceGrass	0.425	0.132	3.205	0.001
df:surfaceHard	0.107	0.082	1.297	0.195

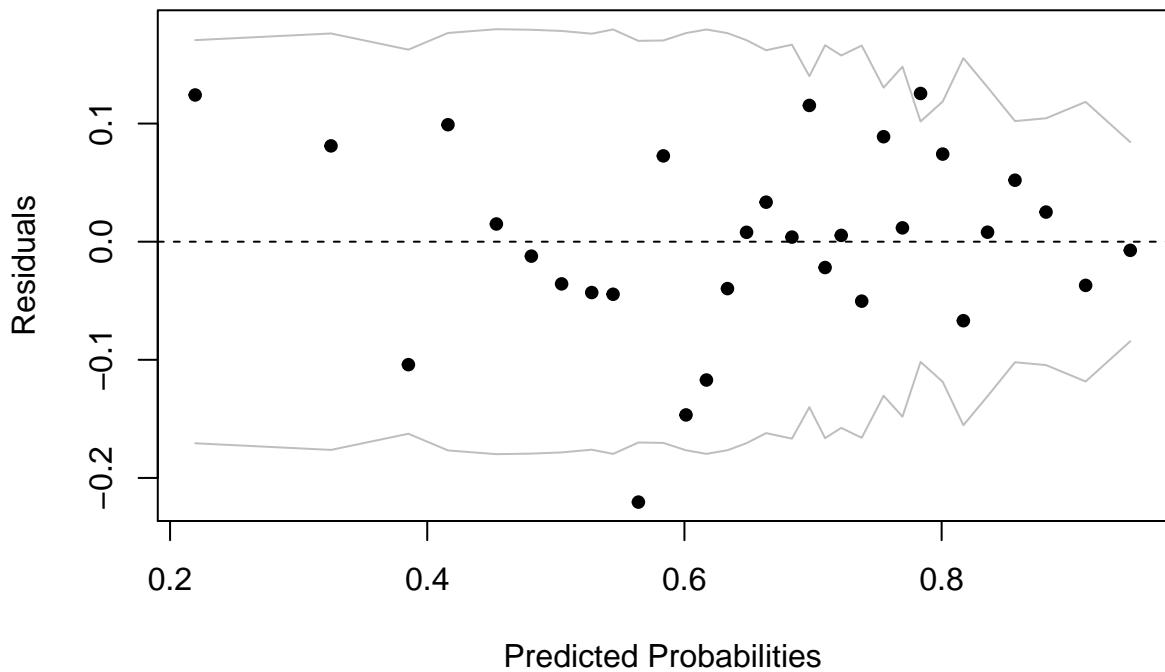
Model Assessment

Binned Plots with Residuals vs Predicted

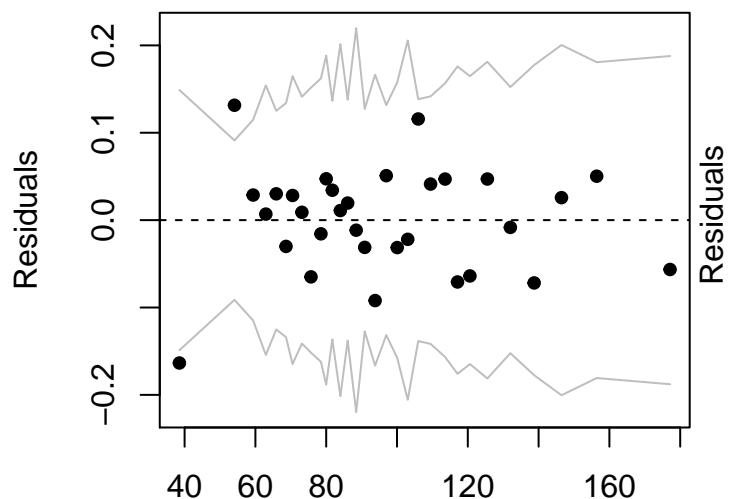
```
ten <- ten %>% mutate(Residuals = residuals.glm(final.base.model,type="response"),
                       Predicted = predict.glm(final.base.model,type="response"))

binnedplot(ten$Predicted, ten$Residuals,xlab="Predicted Probabilities",
           ylab="Residuals",main="Binned Residuals vs. Predicted Probabilities")
```

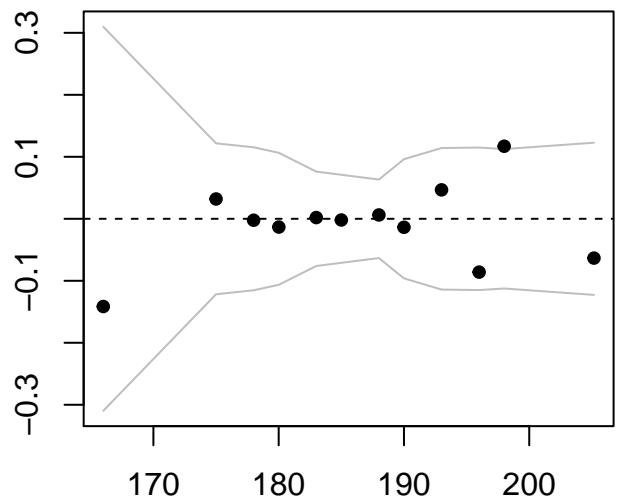
Binned Residuals vs. Predicted Probabilities



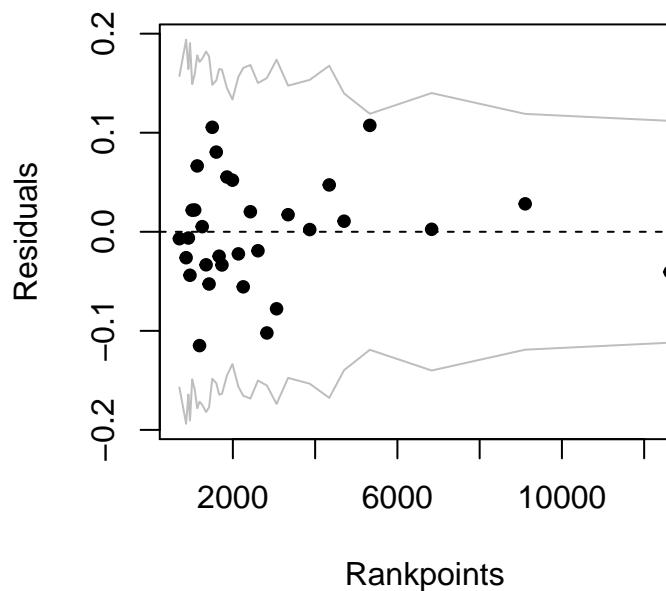
Binned Residuals vs. Minutes



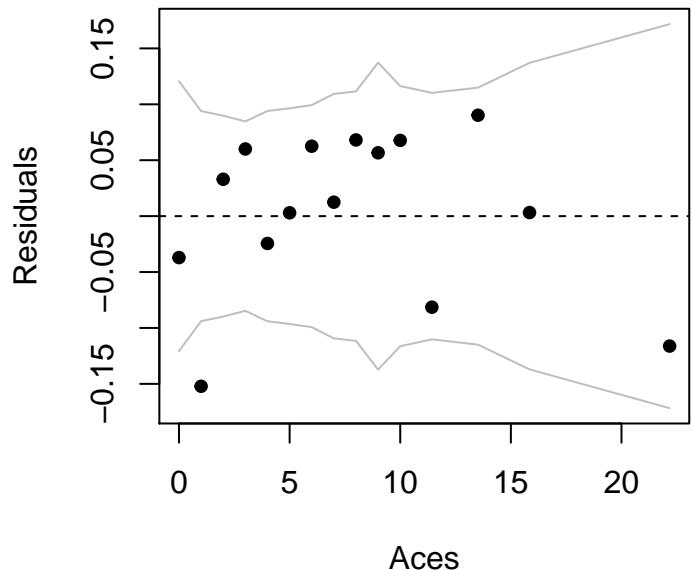
Binned Residuals vs. Height



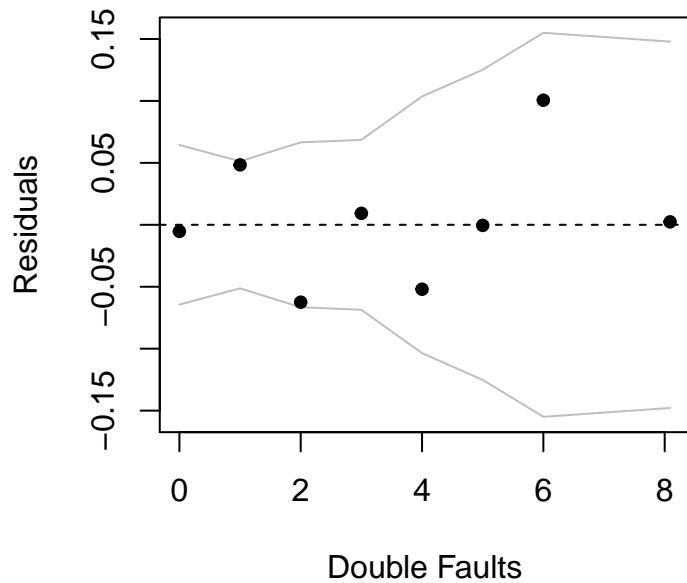
Binned Residuals vs. Rankpoints



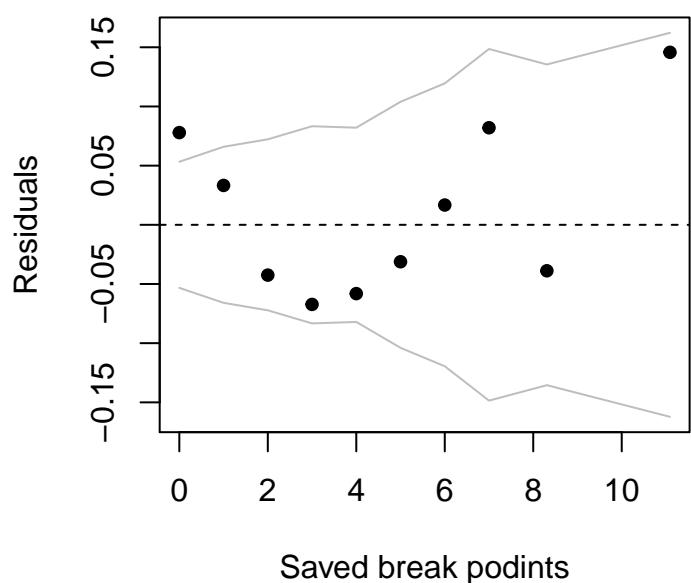
Binned Residuals vs. Aces



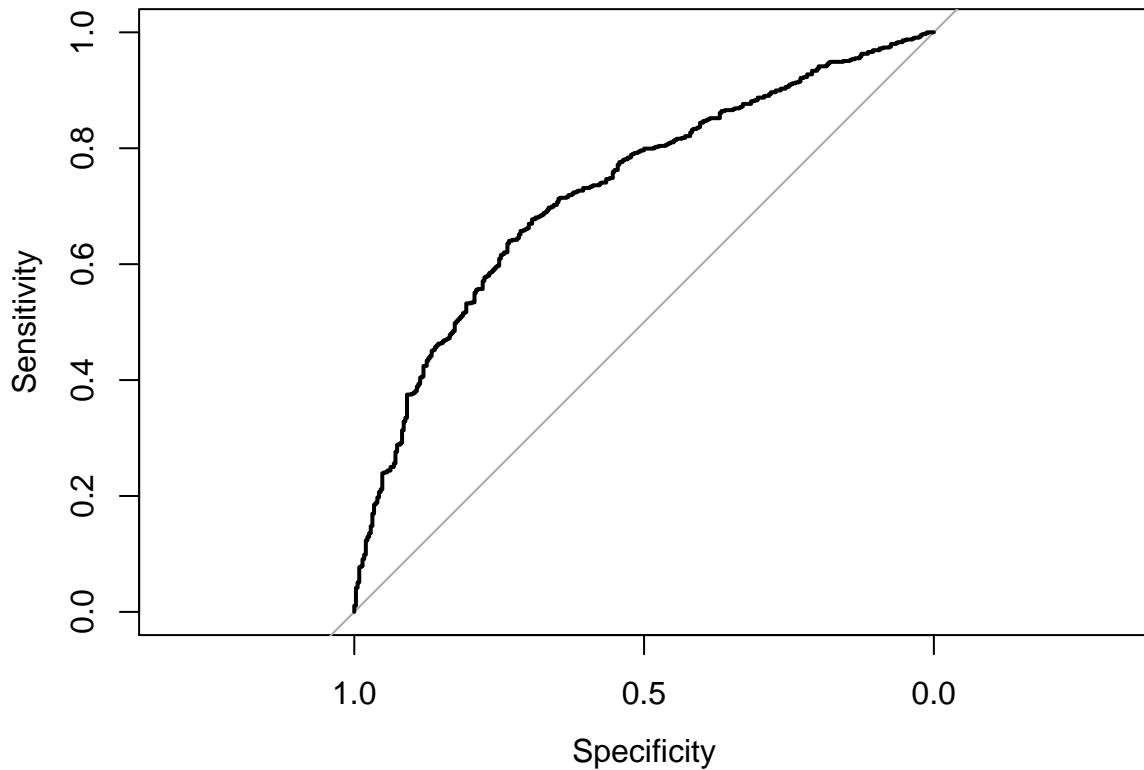
Binned Residuals vs. Double Faults



Binned Residuals vs. Saved break po



```
ROC.ten <- roc(ten$status, ten$Predicted, plot=T)
```



```
ROC.ten$auc
```

```
## Area under the curve: 0.7268
```

```
threshold = 0.30
```

```
table(ten$status, ten$Predicted > threshold)
```

```

##          FALSE TRUE
## 0      26  326
## 1      13  635
(326 + 13)/(14+13+326+635)

## [1] 0.3431174

```

Linear Regression Assumptions: Revised

Unfortunately, one of our residuals plots has a non-linear relationship. Thus, we will remove `bpSaved` from the model.

```

newten <- ten
final <- glm(status ~ minutes + ht + rankpoints + ace + df, family = binomial, data = newten)
kable(tidy(final), format = "markdown", digits = 3)

```

term	estimate	std.error	statistic	p.value
(Intercept)	5.197	1.951	2.664	0.008
minutes	-0.009	0.002	-3.715	0.000
ht	-0.023	0.010	-2.221	0.026
rankpoints	0.000	0.000	5.238	0.000
ace	0.094	0.018	5.371	0.000
df	-0.169	0.036	-4.770	0.000

Model Assessment

Binned Plots with Residuals vs Predicted

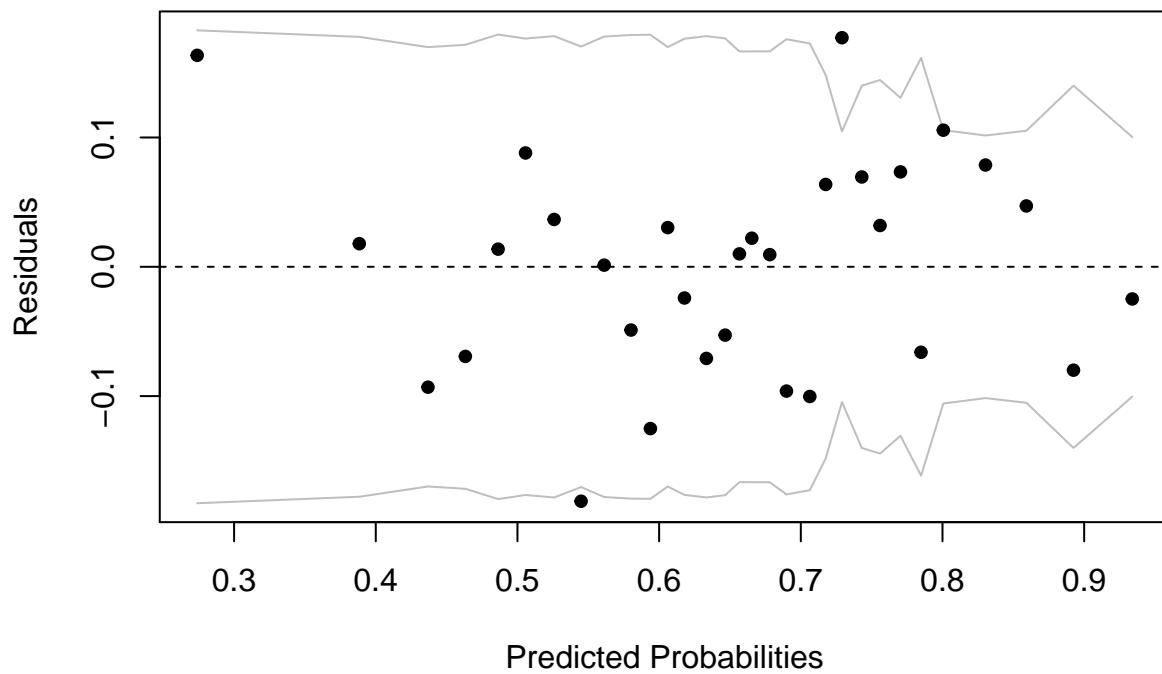
```

newten <- newten %>% mutate(Residuals = residuals.glm(final,type="response"),
                               Predicted = predict.glm(final,type="response"))

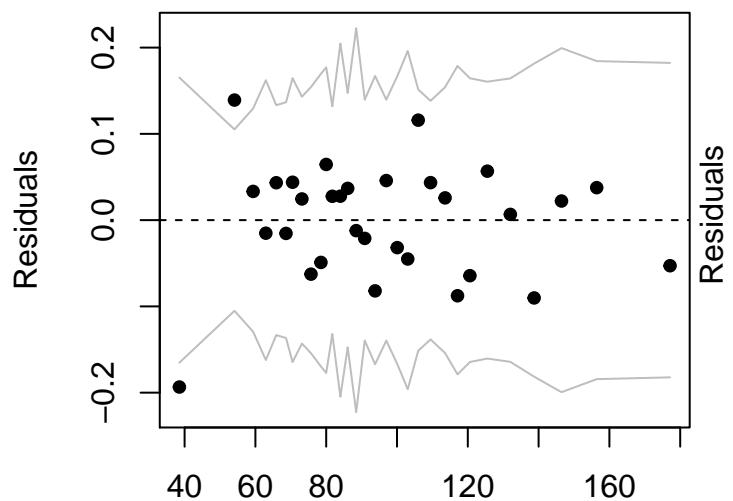
binnedplot(newten$Predicted, newten$Residuals,xlab="Predicted Probabilities",
           ylab="Residuals",main="Binned Residuals vs. Predicted Probabilities")

```

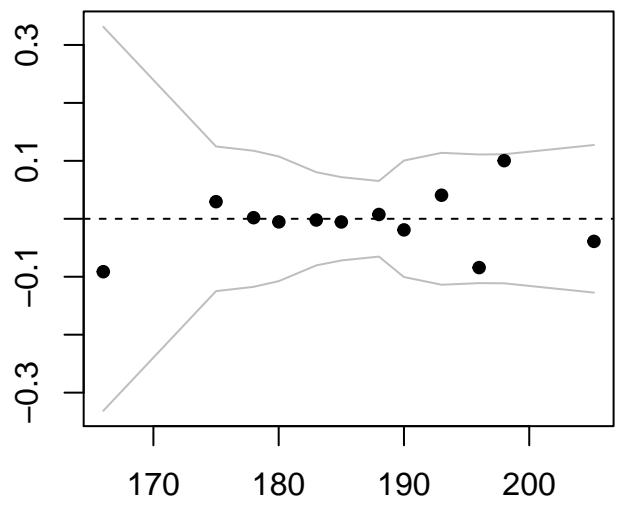
Binned Residuals vs. Predicted Probabilities



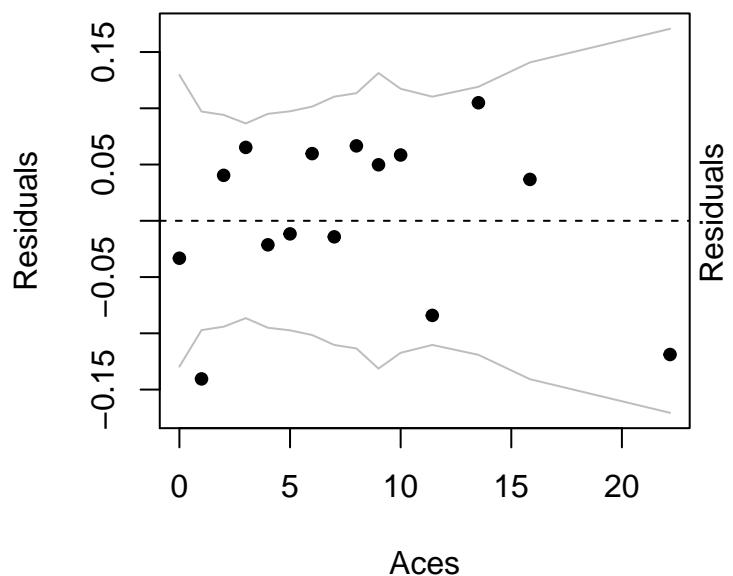
Binned Residuals vs. Minutes



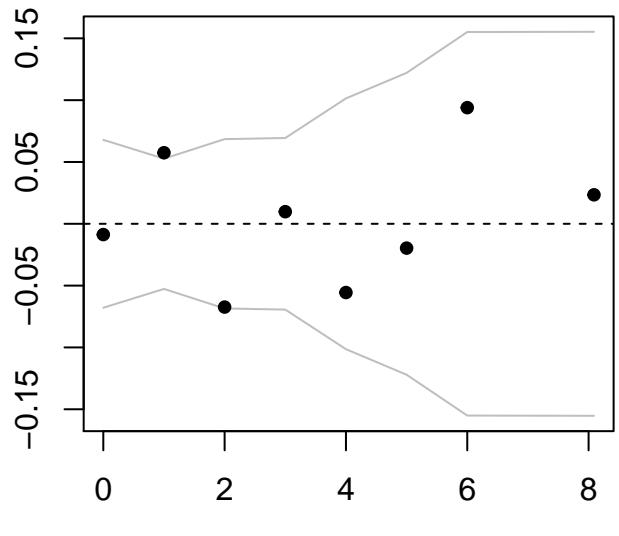
Binned Residuals vs. Height



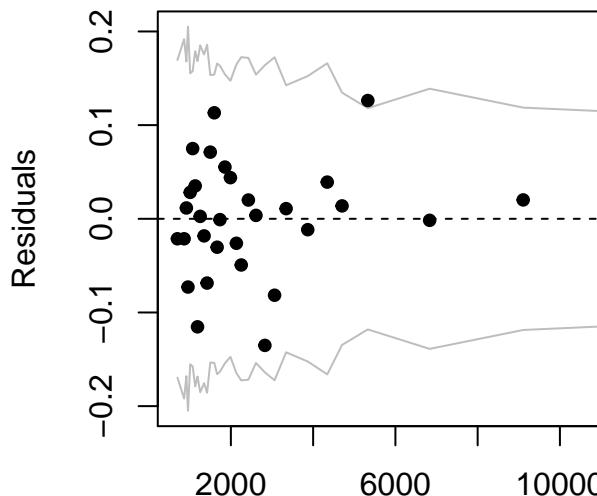
Minutes
Binned Residuals vs. Aces



Height
Binned Residuals vs. Double Faults

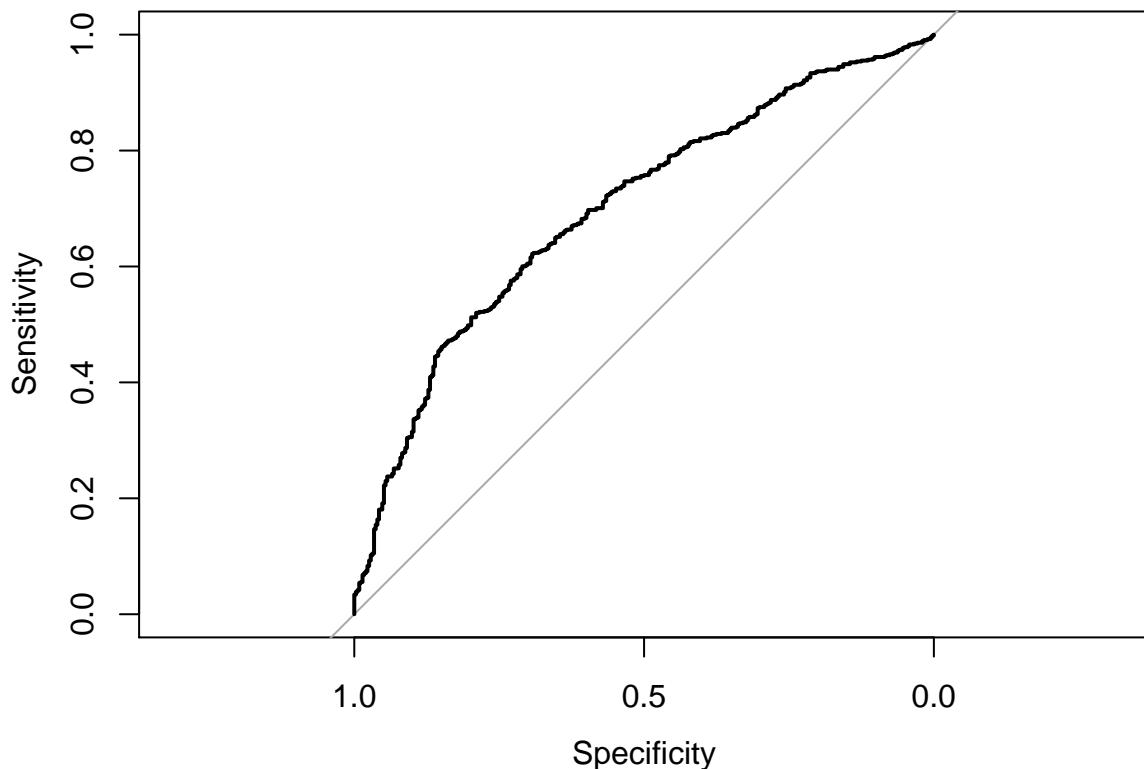


Binned Residuals vs. Rankpoints



Rankpoints

```
ROC.newten <- roc(newten$status,newten$Predicted,plot=T)
```



```
ROC.newten$auc
```

```
## Area under the curve: 0.6996
threshold = 0.30
table(newten$status, newten$Predicted > threshold)
```

```

##          FALSE TRUE
## 0      10  342
## 1      10  638
(342 + 10)/(342 + 10 + 10 + 638)

## [1] 0.352

```

Prediction

Test cases:

We will look at a match that was played the Monte Carlo Masters in 2014 between Roger Federer and Novak Djokovic. We want to see the probability that a player will win the match.

```

tennis %>%
  filter(tourney_name == "Monte Carlo Masters",
         name == "Roger Federer" | name == "Novak Djokovic",
         tourney_id == "2014-410",
         loser_name == "Novak Djokovic")

## # A tibble: 2 x 66
##   tourney_id tourney_name surface draw_size tourney_level tourney_date
##       <chr>     <chr>      <chr>      <int> <chr>           <int>
## 1 2014-410  Monte Carlo~ Clay          56 M            20140413
## 2 2014-410  Monte Carlo~ Clay          56 M            20140413
## # ... with 60 more variables: match_num <int>, winner_id <int>,
## #   winner_seed <int>, winner_entry <chr>, winner_name <chr>,
## #   winner_hand <chr>, winner_ht <int>, winner_ioc <chr>,
## #   winner_age <dbl>, winner_rank <int>, winner_rank_points <int>,
## #   loser_id <int>, loser_seed <int>, loser_entry <chr>, loser_name <chr>,
## #   loser_hand <chr>, loser_ht <int>, loser_ioc <chr>, loser_age <dbl>,
## #   loser_rank <int>, loser_rank_points <int>, score <chr>, best_of <int>,
## #   round <chr>, minutes <int>, w_ace <int>, w_df <int>, w_svpt <int>,
## #   w_1stIn <int>, w_1stWon <int>, w_2ndWon <int>, w_SvGms <int>,
## #   w_bpSaved <int>, w_bpFaced <int>, l_ace <int>, l_df <int>,
## #   l_svpt <int>, l_1stIn <int>, l_1stWon <int>, l_2ndWon <int>,
## #   l_SvGms <int>, l_bpSaved <int>, l_bpFaced <int>, seed <int>,
## #   name <chr>, hand <chr>, ht <int>, age <dbl>, rank <int>,
## #   rankpoints <int>, ace <int>, df <int>, svpt <int>, firsstIn <int>,
## #   firsttWon <int>, secondndWon <int>, SvGms <int>, bpSaved <int>,
## #   bpFaced <int>, status <dbl>

fed <- data.frame(minutes = 75, ht = 185, rankpoints = 5355, ace = 3, df = 1)
djo1 <- data.frame(minutes = 75, ht = 188, rankpoints = 11680, ace = 2, df = 0)
predict.glm(final, newdata=fed, type="response")

##          1
## 0.7937041

predict.glm(final, newdata=djo1, type="response")

##          1
## 0.9251785

```

We see that the model predicts Roger Federer has a 79.37% chance of winning the match, while Novak Djokovic has a 92.52% chance of winning the match. This is mainly because Djokovic's rank points were almost double that of Federer's at the time. However, Federer won the match. In this case, we had an anomaly.

The next match we will look at was played at the China Open in 2013 and was between Novak Djokovic and Rafael Nadal.

```
tennis %>%
  filter(name == "Novak Djokovic" | name == "Rafael Nadal",
        tourney_name == "Beijing",
        loser_name == "Rafael Nadal",
        tourney_id == "2013-747")

## # A tibble: 2 x 66
##   tourney_id tourney_name surface draw_size tourney_level tourney_date
##   <chr>      <chr>      <chr>     <int> <chr>           <int>
## 1 2013-747   Beijing     Hard       32 A            20130930
## 2 2013-747   Beijing     Hard       32 A            20130930
## # ... with 60 more variables: match_num <int>, winner_id <int>,
## #   winner_seed <int>, winner_entry <chr>, winner_name <chr>,
## #   winner_hand <chr>, winner_ht <int>, winner_ioc <chr>,
## #   winner_age <dbl>, winner_rank <int>, winner_rank_points <int>,
## #   loser_id <int>, loser_seed <int>, loser_entry <chr>, loser_name <chr>,
## #   loser_hand <chr>, loser_ht <int>, loser_ioc <chr>, loser_age <dbl>,
## #   loser_rank <int>, loser_rank_points <int>, score <chr>, best_of <int>,
## #   round <chr>, minutes <int>, w_ace <int>, w_df <int>, w_svpt <int>,
## #   w_1stIn <int>, w_1stWon <int>, w_2ndWon <int>, w_SvGms <int>,
## #   w_bpSaved <int>, w_bpFaced <int>, l_ace <int>, l_df <int>,
## #   l_svpt <int>, l_1stIn <int>, l_1stWon <int>, l_2ndWon <int>,
## #   l_SvGms <int>, l_bpSaved <int>, l_bpFaced <int>, seed <int>,
## #   name <chr>, hand <chr>, ht <int>, age <dbl>, rank <int>,
## #   rankpoints <int>, ace <int>, df <int>, svpt <int>, firsstIn <int>,
## #   firsttWon <int>, secondndWon <int>, SvGms <int>, bpSaved <int>,
## #   bpFaced <int>, status <dbl>
djo2 <- data.frame(minutes = 87, ht = 188, rankpoints = 11120, ace = 5, df = 1)
nadal <- data.frame(minutes = 87, ht = 185, rankpoints = 10860, ace = 2, df = 2)
predict.glm(final, newdata=djo2, type="response")

##          1
## 0.9182071

predict.glm(final, newdata=nadal, type="response")

##          1
## 0.8795555
```

We see that the model predicts Novak Djokovic has a 91.82% chance of winning the match, while Rafael Nadal has a 87.96% chance of winning the match. Djokovic won the match.

Test Case with Similar Rank Points

Now, we'll look at a match where both players had similar rank points. The match we will look at is between Jo Wilfried Tsonga and Michael Llodra, and was played at the Queen's Club Championships in 2011.

```

ten %>%
  filter(winner_rank_points > 1000 & winner_rank_points < 2000 & loser_rank_points > 1000 & loser_rank_
    tourney_id == "2011-311",
    tourney_name == "Queen's Club",
    winner_name == "Jo Wilfried Tsonga"
  )

## # A tibble: 1 x 68
##   tourney_id tourney_name surface draw_size tourney_level tourney_date
##   <chr>      <chr>       <chr>     <int> <chr>           <int>
## 1 2011-311  Queen's Club Grass      56 A             20110606
## # ... with 62 more variables: match_num <int>, winner_id <int>,
## #   winner_seed <int>, winner_entry <chr>, winner_name <chr>,
## #   winner_hand <chr>, winner_ht <int>, winner_ioc <chr>,
## #   winner_age <dbl>, winner_rank <int>, winner_rank_points <int>,
## #   loser_id <int>, loser_seed <int>, loser_entry <chr>, loser_name <chr>,
## #   loser_hand <chr>, loser_ht <int>, loser_ioc <chr>, loser_age <dbl>,
## #   loser_rank <int>, loser_rank_points <int>, score <chr>, best_of <int>,
## #   round <chr>, minutes <int>, w_ace <int>, w_df <int>, w_svpt <int>,
## #   w_1stIn <int>, w_1stWon <int>, w_2ndWon <int>, w_SvGms <int>,
## #   w_bpSaved <int>, w_bpFaced <int>, l_ace <int>, l_df <int>,
## #   l_svpt <int>, l_1stIn <int>, l_1stWon <int>, l_2ndWon <int>,
## #   l_SvGms <int>, l_bpSaved <int>, l_bpFaced <int>, seed <int>,
## #   name <chr>, hand <chr>, ht <int>, age <dbl>, rank <int>,
## #   rankpoints <int>, ace <int>, df <int>, svpt <int>, firsstIn <int>,
## #   firstWon <int>, secondndWon <int>, SvGms <int>, bpSaved <int>,
## #   bpFaced <int>, status <fct>, Residuals <dbl>, Predicted <dbl>
jo <- data.frame(minutes = 23, ht = 188, rankpoints = 1480, ace = 2, df = 1)
llodra <- data.frame(minutes = 23, ht = 190, rankpoints = 1400, ace = 0, df = 0)
predict.glm(final, newdata=jo, type="response")

##          1
## 0.7180615

predict.glm(final, newdata=llodra, type="response")

##          1
## 0.7016269

```

We see that the model predicts Jo Wilfried Tsonga has a 71.81% of chance of winning the match, while Michael Llodra has a 70.16% chance of winning the match. These percentages are lower because the players' rankpoints are significantly lower than those of Nadal's and Djokovic's.

Conclusion