SAP - Projekt

Analiza UFC borbi

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Početna analiza podataka

```
total_fight_data = read.csv("total_fight_data.csv", sep = ";")
dim(total_fight_data)
```

```
## [1] 6012   41
```

```
fighter_details = read.csv("fighter_details.csv", sep = ",")
dim(fighter_details)
```

```
## [1] 3596   14
```

```
all <- merge(total_fight_data, fighter_details, by.x = "R_fighter", by.y = "fighter_name",
    all.x = TRUE)
all <- merge(all, fighter_details, by.x = "B_fighter", by.y = "fighter_name", all.x = TRUE,
    suffixes = c(".r", ".b"))
```

```
dim(all)
```

```
## [1] 6012   67
```

Zadatak 1: Možemo li očekivati završetak borbe knockout-om ovisno o razlici u dužini ruku između boraca?

Početni korak u rješavanju ovog zadatka bila je pretvorba težine, visine i dosega iz imperijalnog sustava oba borca u metrički sustav. Ovdje je prikazana jedna pretvorba, na isti način su napravljene i ostalih 5 pretvorbi. Ignorirali smo sve datapoint-ove sa NA vrijednostima.

```
# Pretvaranje in u cm
all$Height_cm.b = sapply(strsplit(as.character(all$Height.b), "'|\""), function(x) {
    30.48 * as.numeric(x[1]) + 2.54 * as.numeric(x[2])
})
```

```
# Micanje redaka koji imaju NA reach
all_without_na_in_reach <- subset(all, !is.na(Reach_cm.b))
all_without_na_in_reach <- subset(all_without_na_in_reach, !is.na(Reach_cm.r))
```

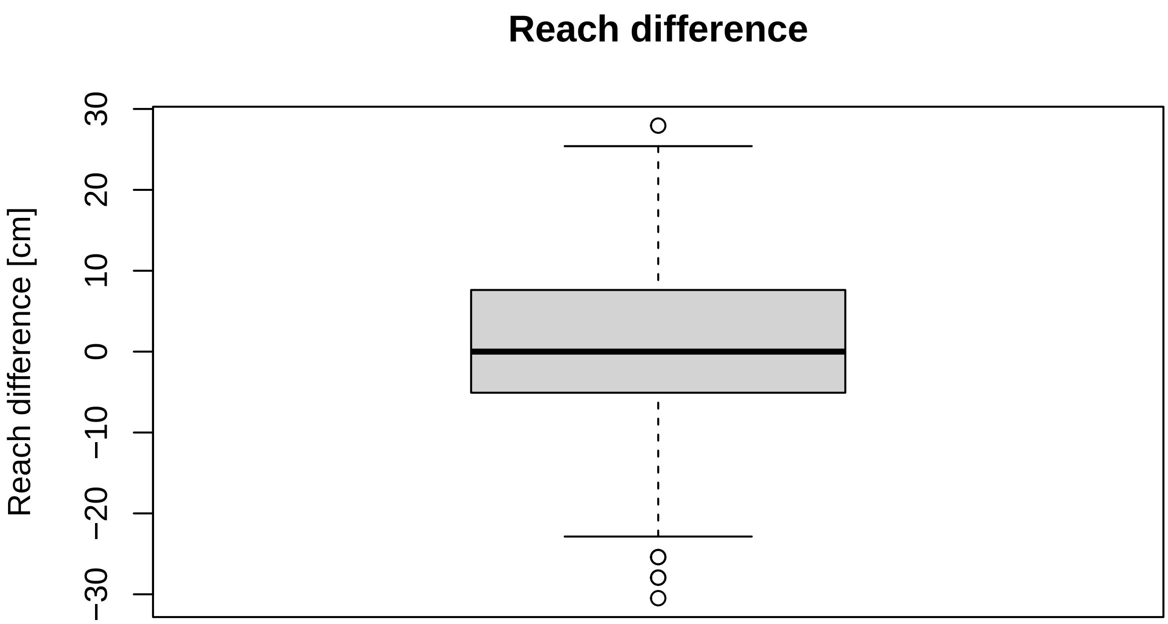
```
# Samo borbe koje su završile knockout-om
all_only_knockouts = subset(all_without_na_in_reach, all_without_na_in_reach$win_by ==
    "KO/TKO")
```

```
# Računanje razlike dosega pobjednika i gubitnika
d = c()
for (i in 1:nrow(all_only_knockouts)) {
```

```
    row = all_only_knockouts[i, ]
    diff = row$Reach_cm.r - row$Reach_cm.b
    if (row$Winner == row$R_fighter) {
        d = append(d, diff)
    } else {
        d = append(d, -diff)
    }
}

summary(d)
```

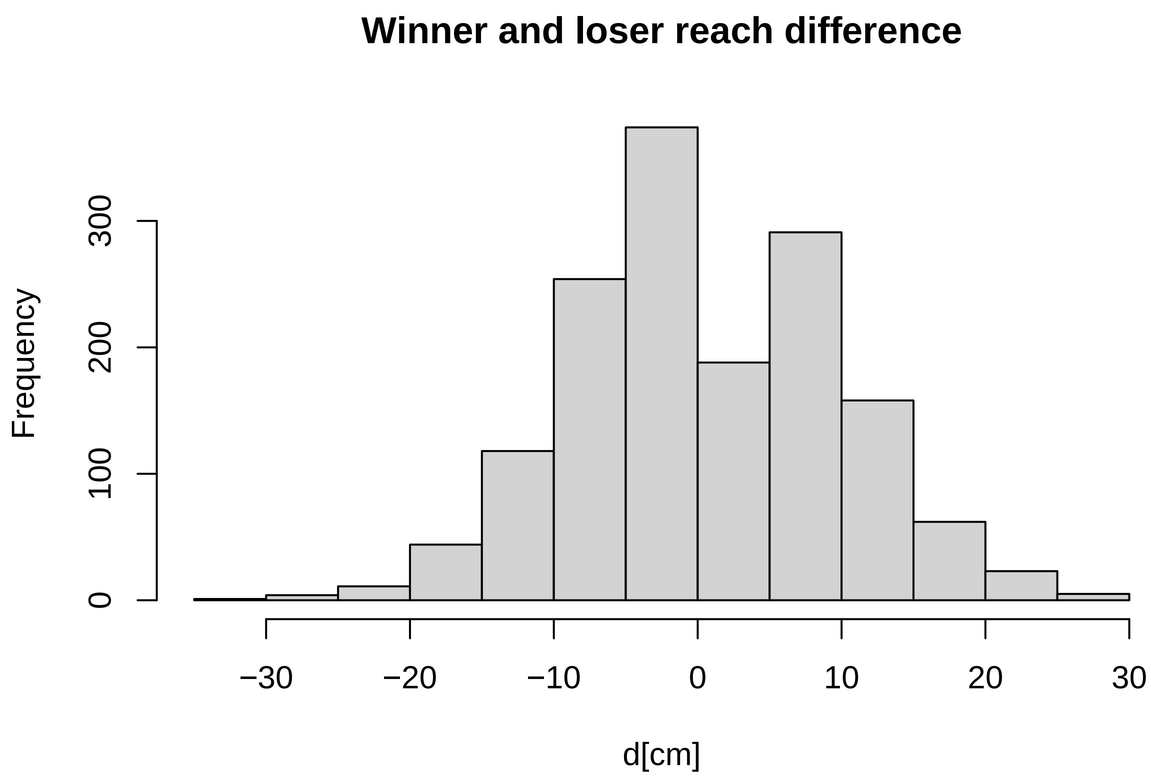
```
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
## -30.4800  -5.0800   0.0000   0.8251   7.6200  27.9400
```

```
boxplot(d, ylab = "Reach difference [cm]", main = "Reach difference")
```

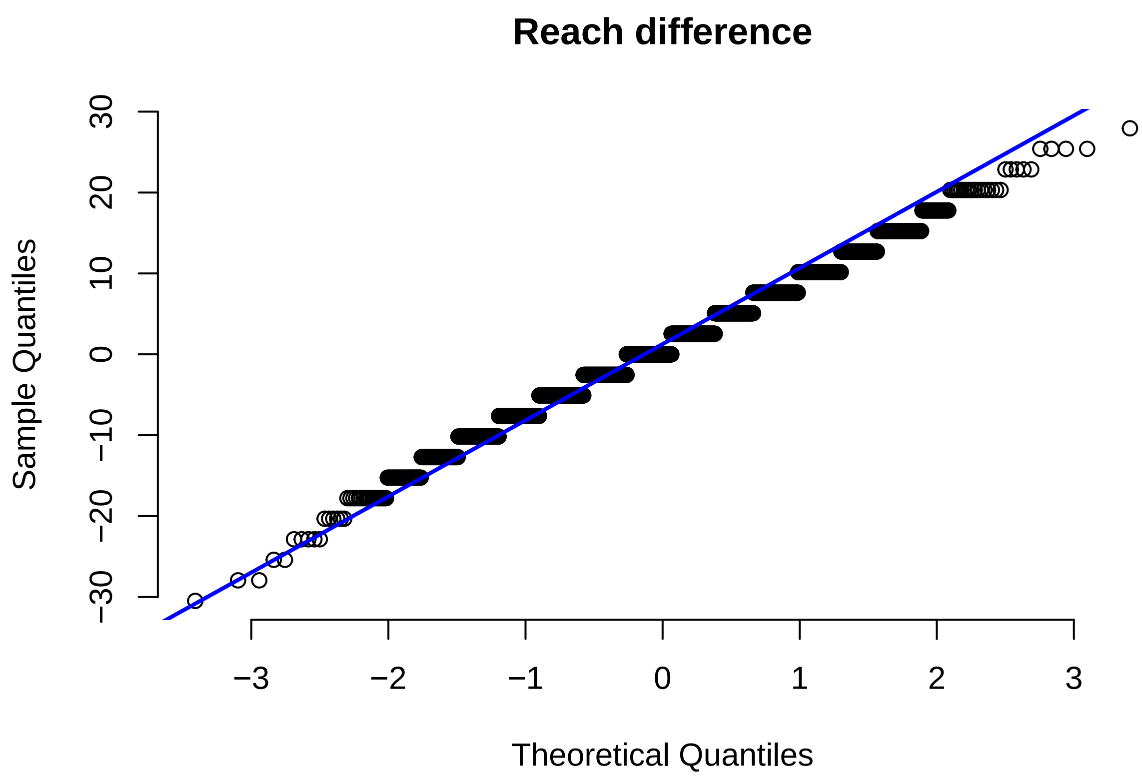


Kako bi mogli primjeniti t-test, prvo je potrebno provjeriti normalnost razdiobe podataka.

```
hist(d, main = "Winner and loser reach difference", xlab = "d[cm]")
```




```
qqnorm(d, pch = 1, frame = FALSE, main = "Reach difference")
qqline(d, col = "blue", lwd = 2)
```



Iz histograma i Q-Q plota, možemo zaključiti da su podaci normalno distribuirani, te primjenjujemo t-test. - H0: Razlika u dosegu između pobjednika i gubitnika jednaka je nuli. - H1: Pobjednici imaju veći doseg od gubitnika.

```
t.test(d, alternative = "greater", mu = 0, conf.level = 0.95)
```

```
##
##  One Sample t-test
##
## data:  d
## t = 3.8558, df = 1532, p-value = 6.006e-05
## alternative hypothesis: true mean is greater than 0
## 95 percent confidence interval:
##  0.4729235       Inf
## sample estimates:
## mean of x
## 0.8251272
```

S razinom značajnosti $\alpha = 0.05$ možemo odbaciti hipotezu H0 u korist hipoteze H1.

Zadatak 2: Razlikuje li se trajanje borbi (s) između pojednih kategorija?

Najprije smo iz zapisa formata borbe i trajanja zadnje runde izračunali sveukupno trajanje borbe.

```
# Računanje ukupnog trajanja borbe
fight_length <- function(parsed_format, last_round, last_round_time) {
    if (parsed_format[1] == "No Time Limit") {
        return(convert_string_time_to_seconds(last_round_time))
    }
    if (last_round == 1) {
        return(convert_string_time_to_seconds(last_round_time))
    }
    total_time = 0
    for (i in 1:(last_round - 1)) {
        total_time = total_time + parsed_format[i] * 60
    }

    total_time = total_time + convert_string_time_to_seconds(last_round_time)
    return(total_time)
}

# Na temelju retka računanje ukupnog trajanja borbe
time_from_row <- function(row) {
    parsed_format = parse_format(row$Format)
    last_round = row$last_round
    last_round_time = row$last_round_time
    return(fight_length(parsed_format, last_round, last_round_time))
}

# Računanje vektora trajanja borbe za svaki redak tablice
dur = c()
for (i in 1:nrow(all)) {
    dur = append(dur, time_from_row(all[i, ]))
}

# Dodavanje stupca ukupnog trajanja borbe u sekundama
all$Fight_duration_s <- dur
```

```r
# Grupiranje po kategorijama (odvojeno po spolu)
men_classes = c("Light Heavyweight", "Open Weight", "Lightweight", "Heavyweight",
    "Featherweight", "Bantamweight", "Welterweight", "Middleweight", "Flyweight")
women_classes = c("Women's Bantamweight", "Women's Strawweight", "Women's Featherweight",
    "Women's Flyweight")

# Funkcija za string s vraća TRUE ako sadrži neku od prije navedenih klasa
# (men_classes, women_classes)
filter_not_in_classes <- function(s) {
    for (w in women_classes) {
        if (grepl(w, s)) {
            return(TRUE)
        }
    }
    for (m in men_classes) {
        if (grepl(m, s)) {
            return(TRUE)
        }
    }
    return(FALSE)
}

# Funkcija za string s vraća kategoriju iz men_classes ili women_classes koju
# sadrži
check_which_class <- function(s) {
    for (w in women_classes) {
        if (grepl(w, s)) {
            return(w)
        }
    }
    for (m in men_classes) {
        if (grepl(m, s)) {
            return(m)
        }
    }
}

# Svi tipovi borbi koje ne znamo grupirati u kategorije po težini i spolu
ignore_fight_types = c()
categories = unique(all$Fight_type)
for (category in categories) {
    if (!filter_not_in_classes(category)) {
        ignore_fight_types = append(ignore_fight_types, category)
    }
}

ignore_fight_types
```

```
## [1] "Catch Weight Bout"
## [2] "UFC 4 Tournament Title Bout"
## [3] "UFC Superfight Championship Bout"
## [4] "UFC 5 Tournament Title Bout"
## [5] "UFC 6 Tournament Title Bout"
## [6] "Ultimate Ultimate '96 Tournament Title Bout"
```

```
##  [7] "UFC 10 Tournament Title Bout"
##  [8] "UFC 8 Tournament Title Bout"
##  [9] "UFC 3 Tournament Title Bout"
## [10] "Ultimate Ultimate '95 Tournament Title Bout"
## [11] "UFC 2 Tournament Title Bout"
## [12] "UFC 7 Tournament Title Bout"
```

Pojedine kategorije ne sadržavaju informaciju o spolu i težini te ih stoga ne uzimamo u obzir tokom daljnje analize.

```
# Iz cijelog skupa podataka mičemo borbe čiji je fight_type unutar vektora
# ignore_fight_types
all_without_unknown_weight_classes = subset(all, !(Fight_type %in% ignore_fight_types))
```

Pretpostavke parametarske ANOVA metode su: 1. nezavisnost pojedinih podataka u uzorcima 2. normalna razdioba podataka 3. homogenost varijanci među populacijama

1) Pretpostavljamo nezavisnost podataka u uzorcima, jer su borbe međusobno nezavisne.
2) Nastavaljamo sa testiranjem normalnosti razdiobe podataka. Koristimo Lillieforsov test normalnosti.

- H0: Podaci pripadaju normalnoj razdiobi.
- H1: Podaci ne pripadaju normalnoj razdiobi.

3) Ako razdioba podataka nije normalna, nema smisla provjeravati homoskedastičnost. U drugom slučaju, homoskedastičnost moramo provjeriti Bartlettovim testom.

```
require(nortest)
```

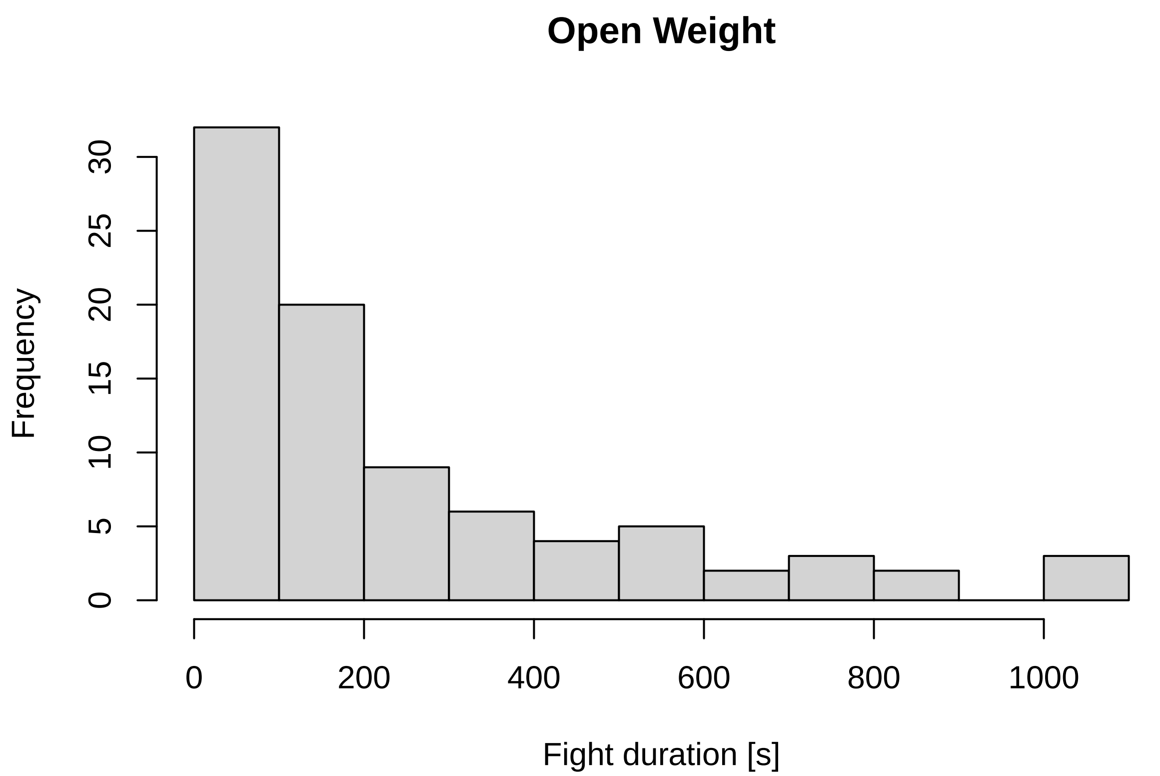
```
## Loading required package: nortest
```

```
lillie.test(all_without_unknown_weight_classes$Fight_duration_s[weight_class == "Open Weight"])
```

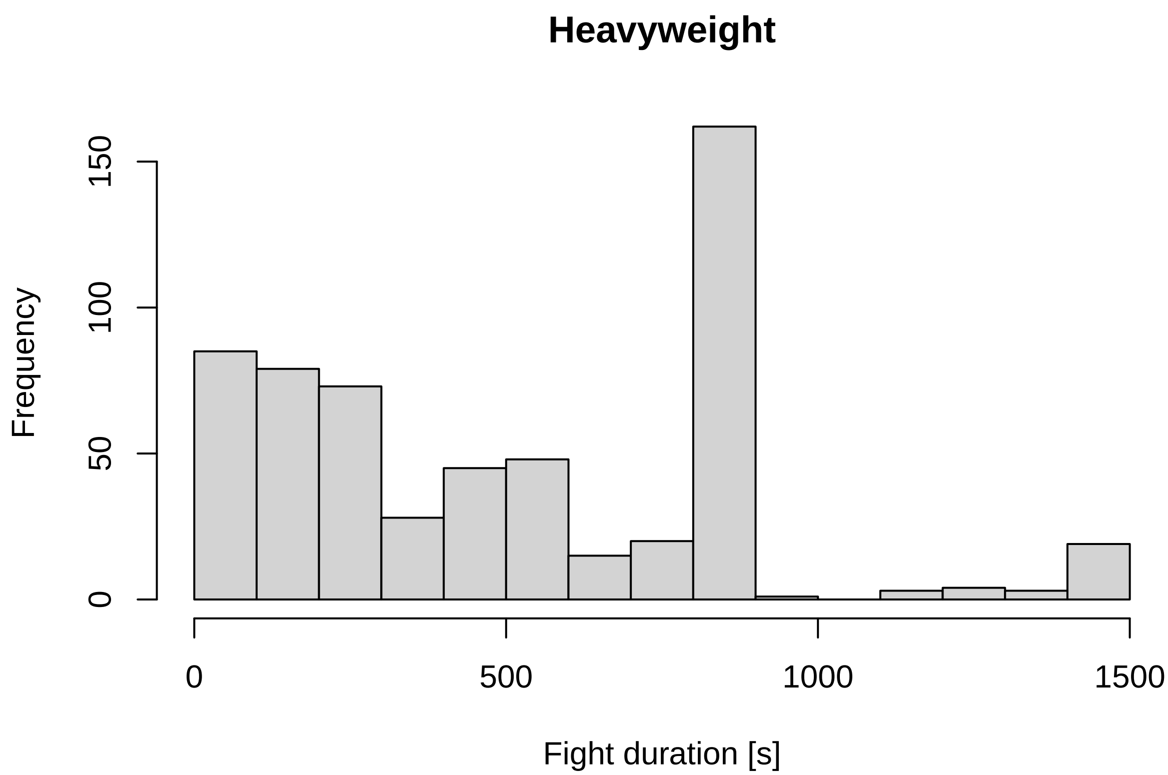
```
##
##  Lilliefors (Kolmogorov-Smirnov) normality test
##
## data:  all_without_unknown_weight_classes$Fight_duration_s[weight_class ==     "Open Weight"]
## D = 0.19826, p-value = 6.363e-09
```

Zbog vrlo male p vrijednosti odbacujemo H0 u korist H1 i zaključujemo da podaci nisu normalno distribuirani. Zato moramo koristiti neparametarsku verziju ANOVA testa, Kruskal-Wallis χ^2-test. Stoga ne testiramo homogenost varijanci među kategorijama.

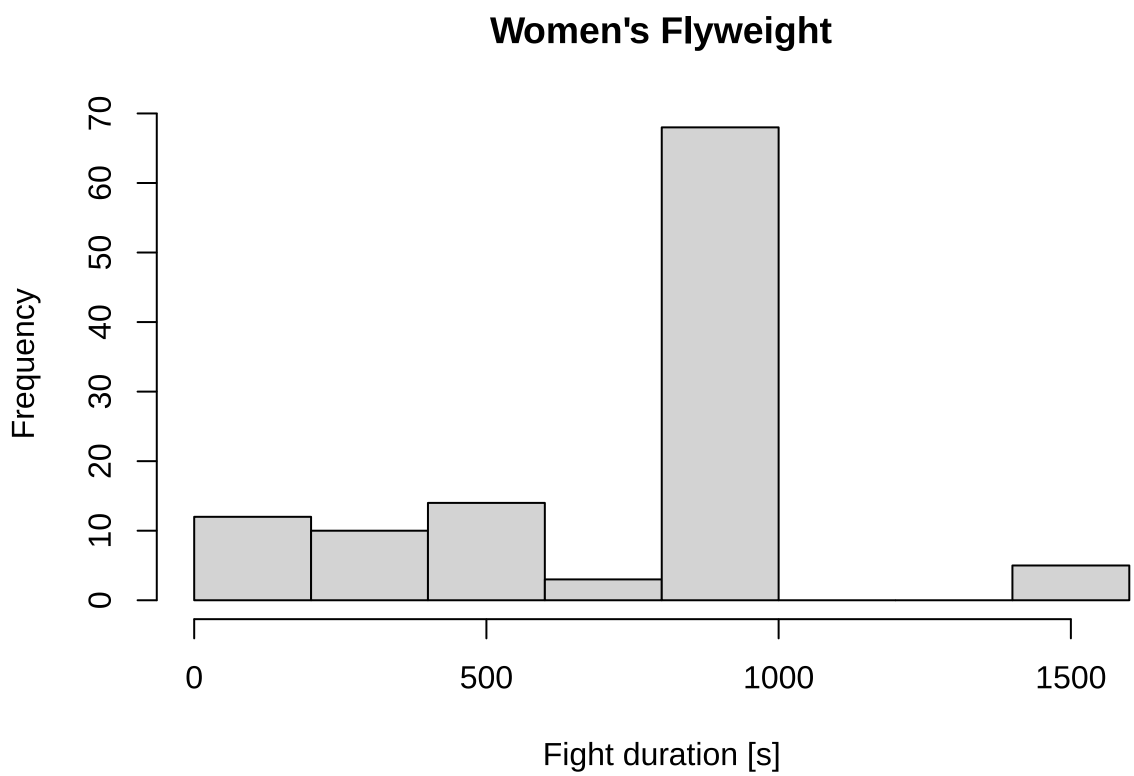
```
# weight_classes = c(men_classes, women_classes)
hist(all_without_unknown_weight_classes$Fight_duration_s[all_without_unknown_weight_classes$weight_class
    "Open Weight"], xlab = "Fight duration [s]", main = "Open Weight")
```




```
hist(all_without_unknown_weight_classes$Fight_duration_s[all_without_unknown_weight_classes$weight_class
    "Heavyweight"], xlab = "Fight duration [s]", main = "Heavyweight")
```




```
hist(all_without_unknown_weight_classes$Fight_duration_s[all_without_unknown_weight_classes$weight_class
    "Women's Flyweight"], xlab = "Fight duration [s]", main = "Women's Flyweight")
```



Iz prikazanih histograma uočavamo da su vremena trajanja borbi sukladna formatima borbi (većina borbi završava u 15. minuti jer su formata 5+5+5 minuta).

Kako bi proveli Kruskal-Wallisov test moramo imati minimalno 5 opservacija u svakoj od kategorija.

```
table(all_without_unknown_weight_classes$weight_class)
```

```
##
##          Bantamweight         Featherweight             Flyweight
##                   475                   551                   230
##           Heavyweight     Light Heavyweight           Lightweight
##                   585                   573                  1091
##          Middleweight           Open Weight          Welterweight
##                   813                    86                  1083
##  Women's Bantamweight Women's Featherweight     Women's Flyweight
##                   151                    16                   112
##   Women's Strawweight
##                   192
```

Postavaljamo hipoteze: - H0: Trajanje borbi se ne razlikuje između kategorija. - H1: Trajanje borbi se razlikuje između barem dvije kategorije.

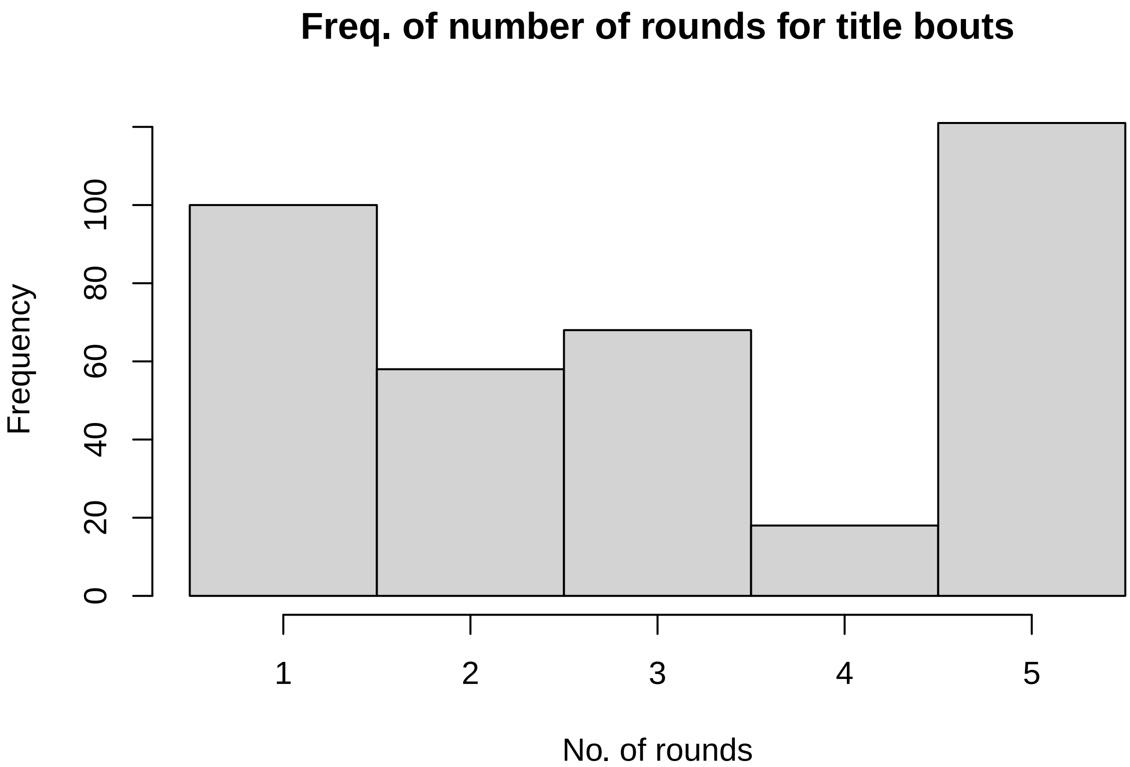
```
kruskal.test(Fight_duration_s ~ weight_class, data = all_without_unknown_weight_classes)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  Fight_duration_s by weight_class
## Kruskal-Wallis chi-squared = 283.65, df = 12, p-value < 2.2e-16
```

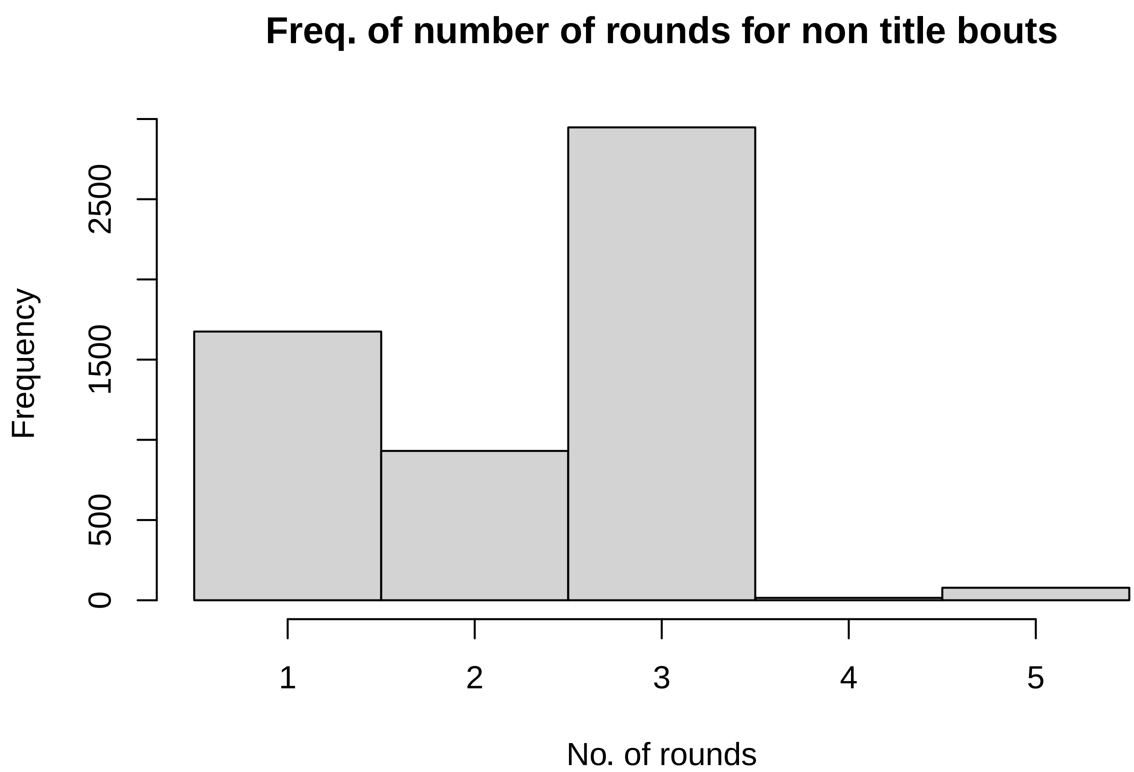
Zbog male p-vrijednosti odbacujemo H0 u korist H1 i zaključujemo da se trajanje borbi statistički značajno razlikuje između barem dvije težinske kategorije.

Zadatak 3: Traju li (u rundama) borbe za titulu duže od ostalih borbi u natjecanju?

```
hist(title_bouts_last_round, breaks = seq(min(title_bouts_last_round) - 0.5, max(title_bouts_last_round)
    0.5, by = 1), main = "Freq. of number of rounds for title bouts", xlab = "No. of rounds")
```




```
hist(non_title_bouts_last_round, breaks = seq(min(non_title_bouts_last_round) - 0.5,
    max(non_title_bouts_last_round) + 0.5, by = 1), main = "Freq. of number of rounds for non title bou
    xlab = "No. of rounds")
```




```r
lillie.test(non_title_bouts_last_round)
```

```
##
##  Lilliefors (Kolmogorov-Smirnov) normality test
##
## data:  non_title_bouts_last_round
## D = 0.31964, p-value < 2.2e-16
```

```r
lillie.test(title_bouts_last_round)
```

```
##
##  Lilliefors (Kolmogorov-Smirnov) normality test
##
## data:  title_bouts_last_round
## D = 0.22181, p-value < 2.2e-16
```

Iz histograma i Lillieforsovog testa vidimo da podaci nisu normalno distribuirani te stoga primjenjujemo neparametarsku verziju t-testa, Wilcoxonov signed rank test. Postavaljamo hipoteze: - H0: Borbe za titulu ne traju duže (u rundama) od ostalih borbi u natjecanju. - H1: Borbe za titulu traju duže (u rundama) od ostalih borbi u natjecanju.

```r
wilcox.test(title_bouts_last_round, non_title_bouts_last_round, alternative = "greater",
    conf.level = 0.9)
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  title_bouts_last_round and non_title_bouts_last_round
## W = 1264014, p-value = 1.3e-15
## alternative hypothesis: true location shift is greater than 0
```

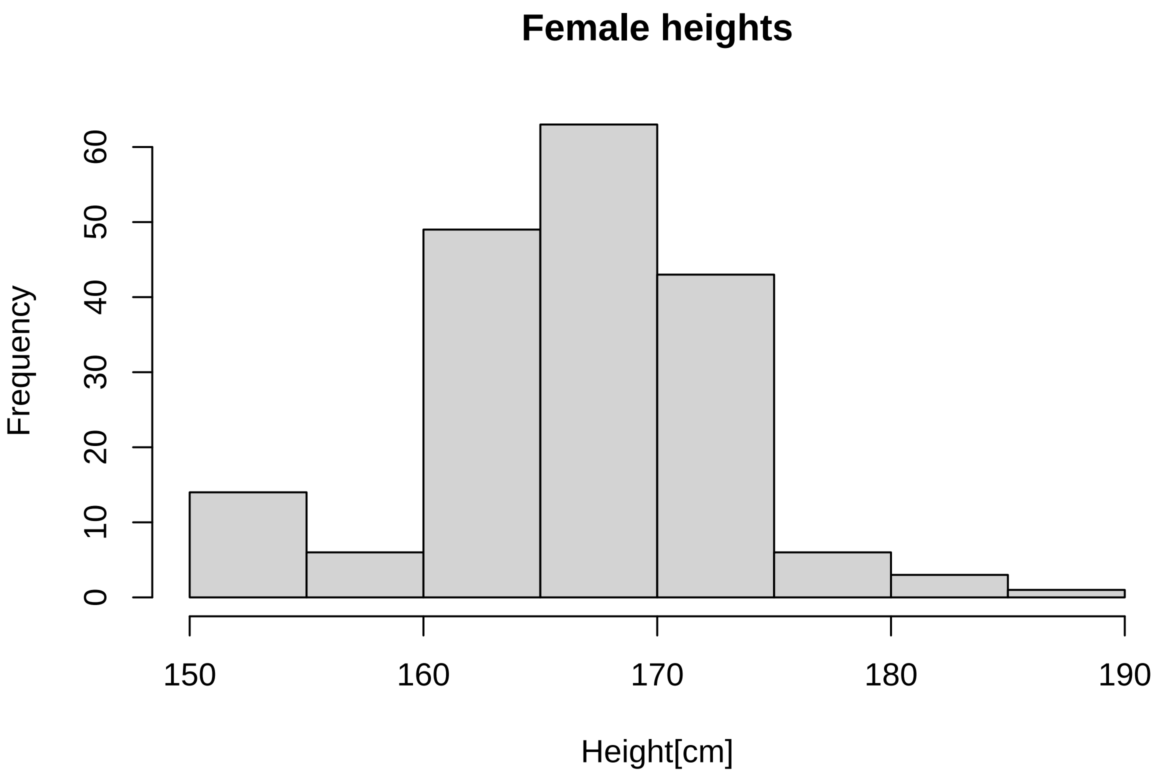
Odabrali smo razinu značajnosti $\alpha = 0.1$ jer želimo veću robustnost testa. Zbog izračunate p-vrijednosti odbacujemo H0 u korist H1 i zaključujemo da borbe za titulu traju duže (u rundama) od ostalih borbi u natjecanju.

Dodatni zadatak 1. - Pobjeđuju li niži borci češće preko submissiona (predaje)?

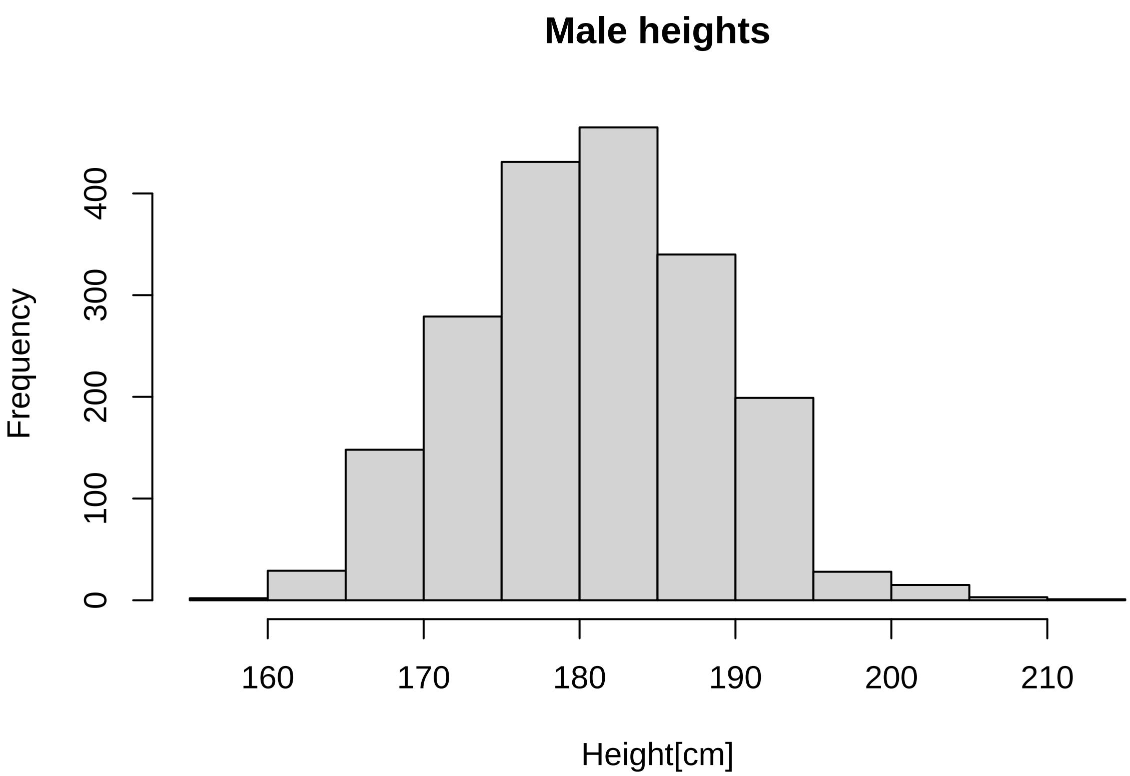
Svim borcima dodali smo obilježje spola koje smo odredili putem imena kategorija borbi u kojima se taj borac borio.

Zatim smo iznos svih visina boraca pretvorili iz imperijalnog sustava mjernih jedinica u metrički.

```
female_heights = subset(fighter_details, gender == "female")$Height_cm
male_heights = subset(fighter_details, gender == "male")$Height_cm
hist(female_heights, main = "Female heights", xlab = "Height[cm]")
```




```
hist(male_heights, main = "Male heights", xlab = "Height[cm]")
```



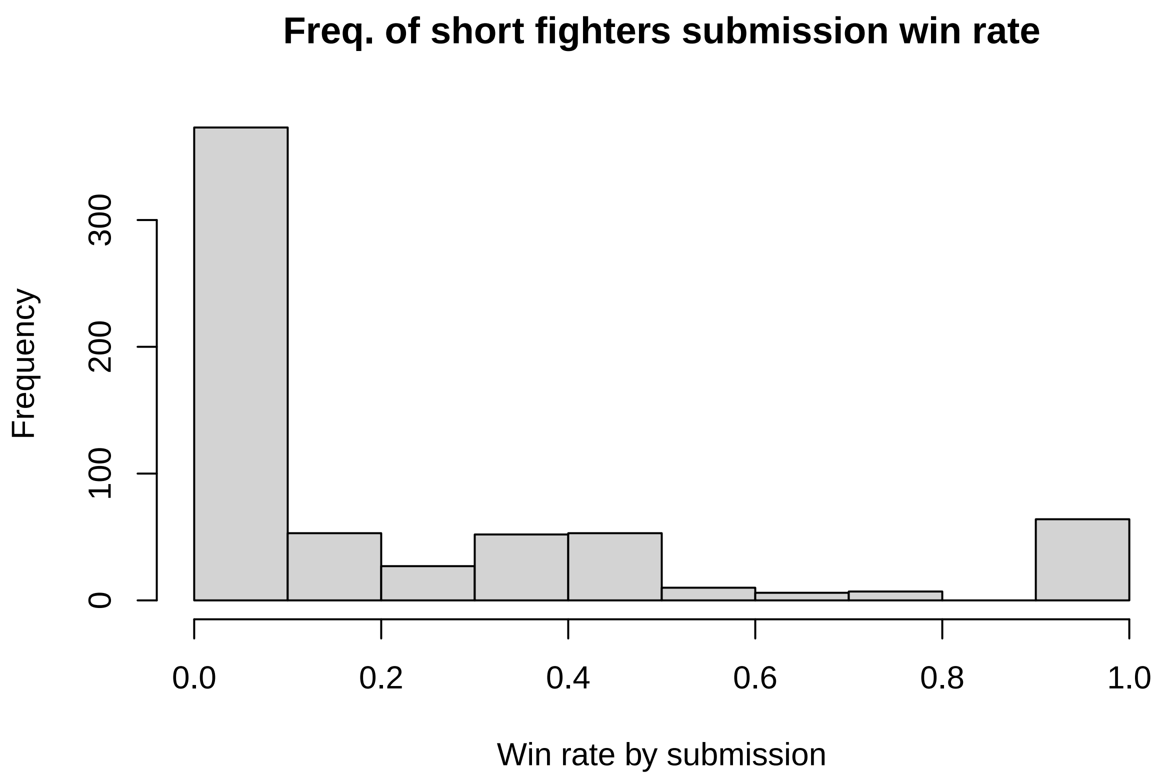
Na temelju medijana svih muških i ženskih visina napravili smo podjelu boraca na niže i više borce, s obzirom na spol.

```
# Određivanje medijana visine za mušku i žensku populaciju
male_median_height = median(male_heights, na.rm = TRUE)
female_median_height = median(female_heights, na.rm = TRUE)

# Određivanje kategorije visine po spolu (short za visine ispod mediana, tall
# za visine iznad mediana)
height_category = c()
for (i in 1:nrow(fighter_details)) {
    if (is.na(fighter_details[i, ]$Height_cm) | is.na(fighter_details[i, ]$gender)) {
        height_category = append(height_category, NA)
        next
    } else {
        if (fighter_details[i, ]$gender == "male") {
            if (fighter_details[i, ]$Height_cm >= male_median_height) {
                height_category = append(height_category, "tall")
            } else {
                height_category = append(height_category, "short")
            }
        } else {
            if (fighter_details[i, ]$Height_cm >= female_median_height) {
                height_category = append(height_category, "tall")
            } else {
                height_category = append(height_category, "short")
            }
        }
    }
}
```

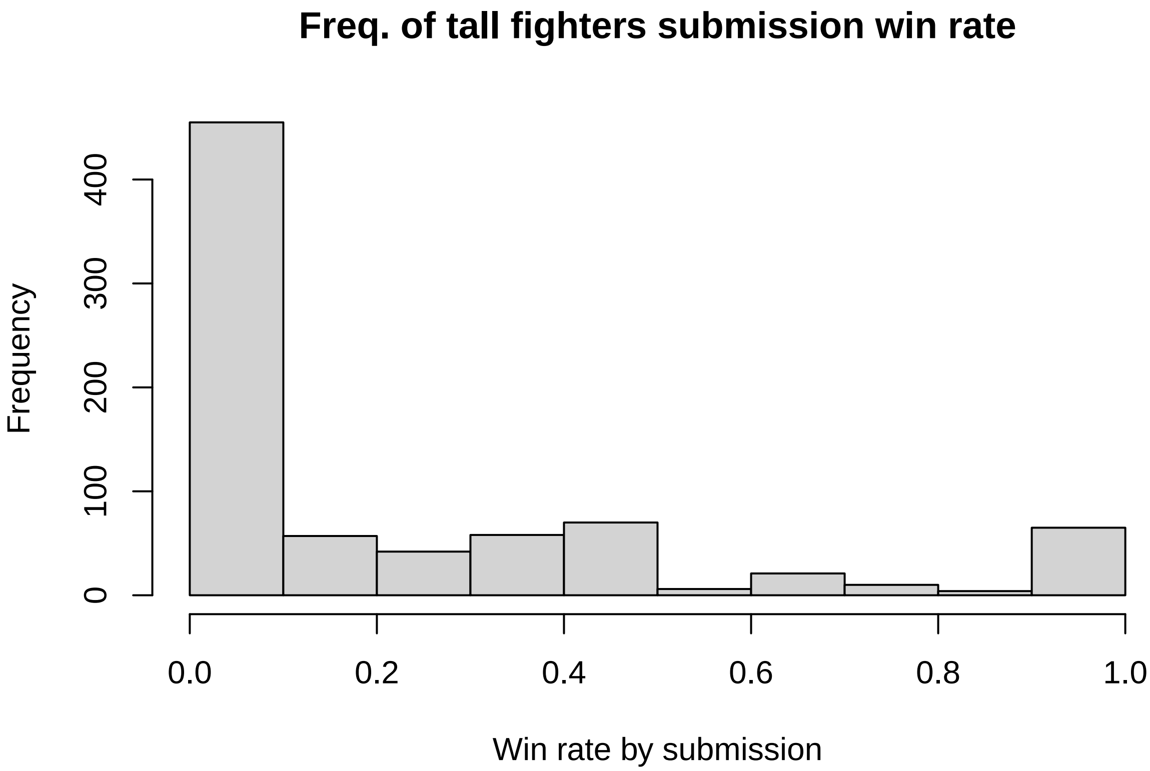
```
# Dodavanje stupca kategorije visine
fighter_details$height_category = height_category
```

Za svakog borca odredili smo postotak njegovih pobjeda putem predaje protivničkog borca. Ukoliko borac nije imao niti jednu pobjedu, postotak pobjeda putem predaje protivnika označili smo sa NA.

```
# Vektor postotaka pobjede putem submissiona za niske borce
short_winners = subset(fighter_details, height_category == "short" & !is.na(win_rate_by_submission))$wi
# Vektori postotaka pobjede putem submissiona za visoke borce
tall_winners = subset(fighter_details, height_category == "tall" & !is.na(win_rate_by_submission))$win_

hist(short_winners, main = "Freq. of short fighters submission win rate", xlab = "Win rate by submissio
```




```
hist(tall_winners, main = "Freq. of tall fighters submission win rate", xlab = "Win rate by submission")
```



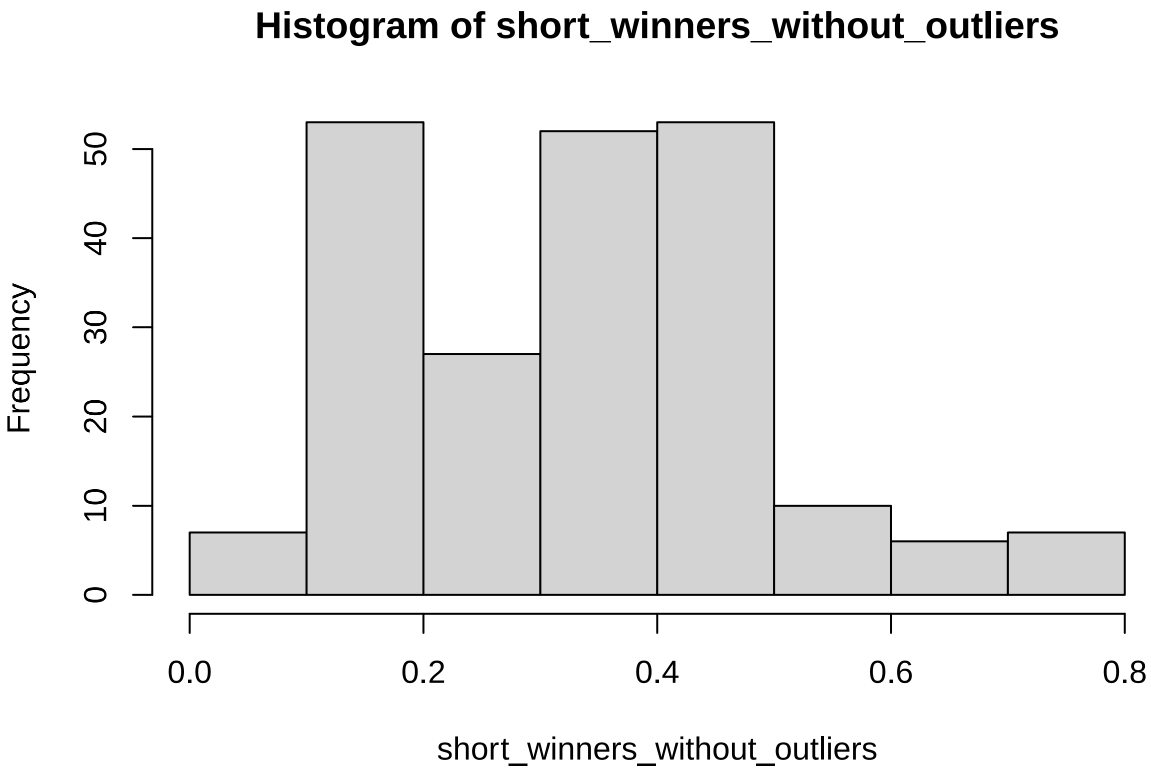
Postavljamo sljedeće hipoteze: - H0: Postotci pobjeda putem submissiona jednaki su za visoke i niske borce. - H1: Postotci pobjeda putem submissiona manji su za visoke borce.

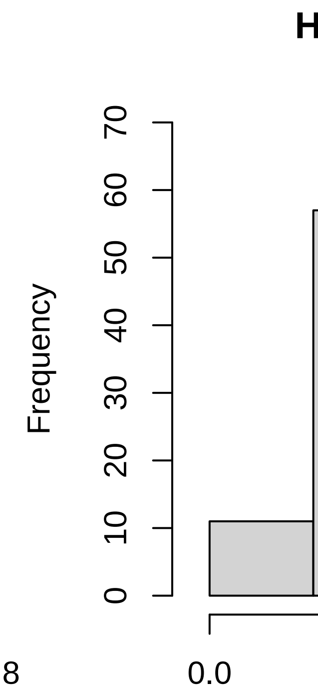
Razinu značajnosti α postavljamo na 0.1 zbog toga što želimo biti manje osjetljivi na ne odbacivanje H0.

```
wilcox.test(tall_winners, short_winners, alternative = "less", conf.level = 0.9)
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  tall_winners and short_winners
## W = 254820, p-value = 0.539
## alternative hypothesis: true location shift is less than 0
```

Na razini značajnosti $\alpha = 0.1$ i dobivene p vrijednosti iz Wilcoxonovog testa sume rangova zaključujemo da ne možemo odbaciti H0 u korist H1 (ne možemo odbaciti hipotezu da su postotci pobjeda putem submissiona jednaki za visoke i niske borce).



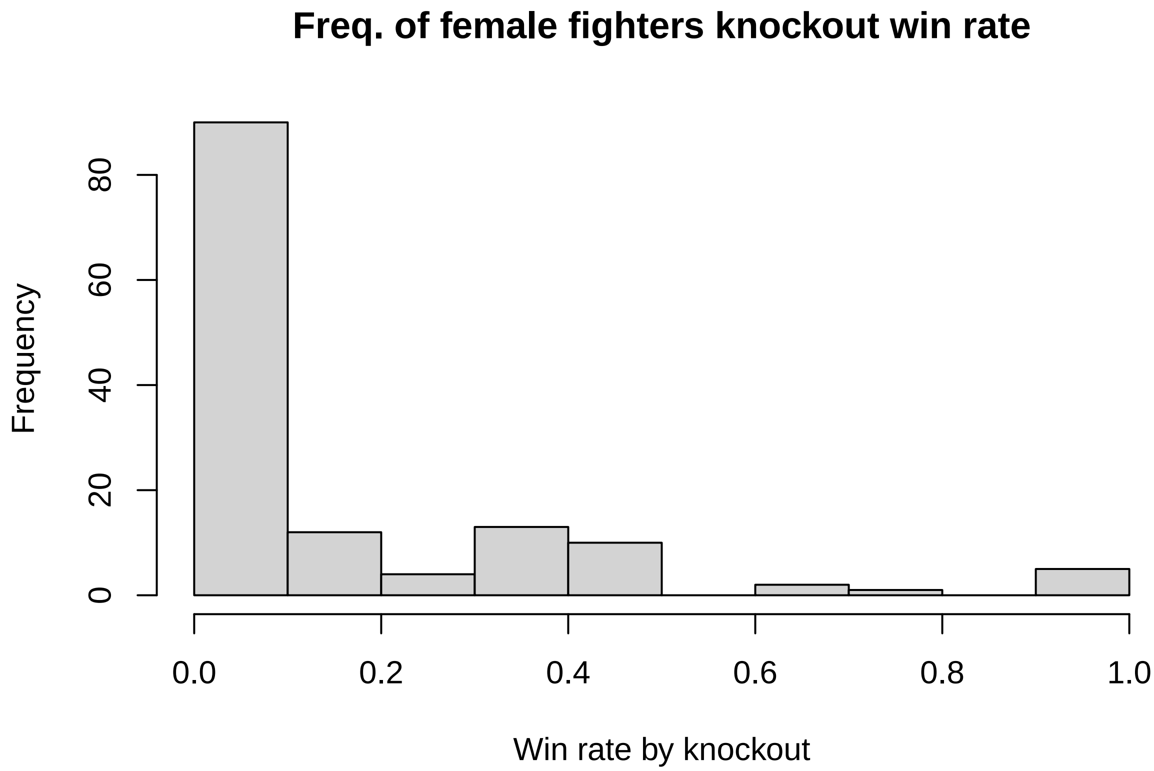



```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  tall_winners_without_outliers and short_winners_without_outliers
## W = 31610, p-value = 0.8501
## alternative hypothesis: true location shift is less than 0
```

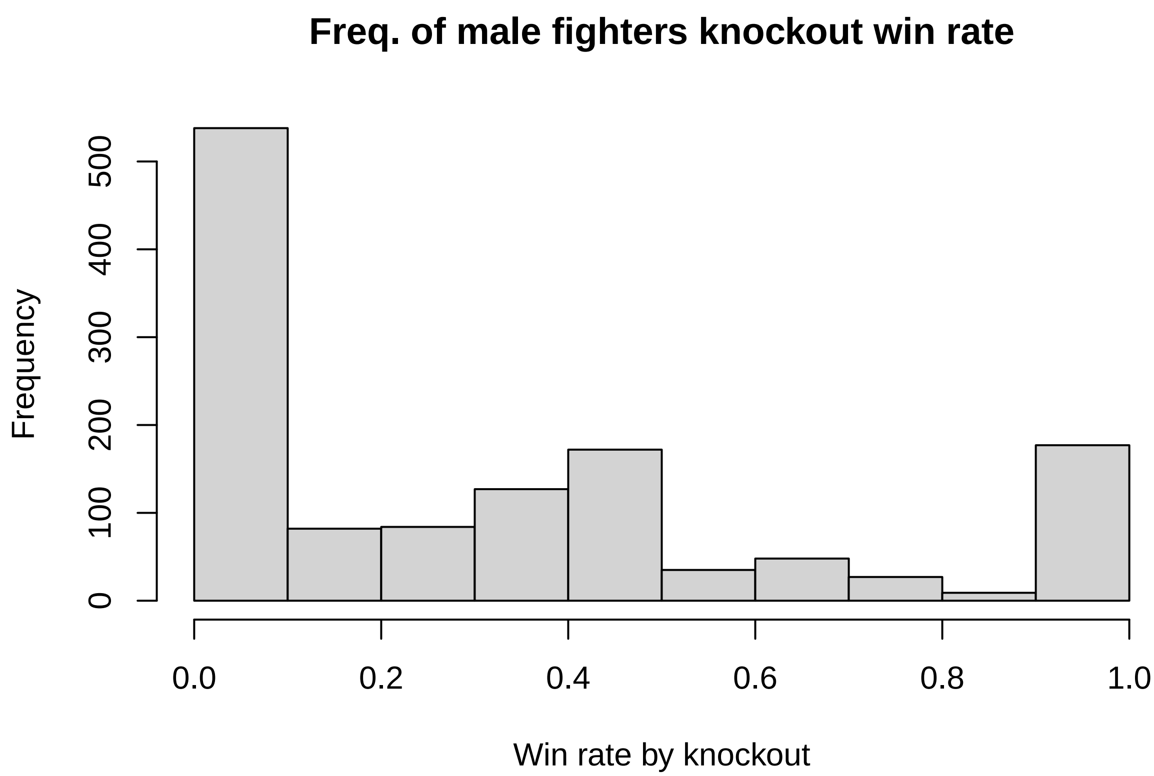
Dodatni zadatak 2. - Završavaju li muške borbe češće nokautom?

Kao i za prethodni zadatak, najprije smo odredili postotak pobjeda svakog borca putem nokauta. Za borca koji nije imao pobjeda, zabilježili smo postotak pobjeda putem nokauta sa NA.

```
female_ko_winners = subset(fighter_details, gender == "female" & !is.na(win_rate_by_ko))$win_rate_by_ko
male_ko_winners = subset(fighter_details, gender == "male" & !is.na(win_rate_by_ko))$win_rate_by_ko

hist(female_ko_winners, main = "Freq. of female fighters knockout win rate", xlab = "Win rate by knocko
```




```
hist(male_ko_winners, main = "Freq. of male fighters knockout win rate", xlab = "Win rate by knockout")
```



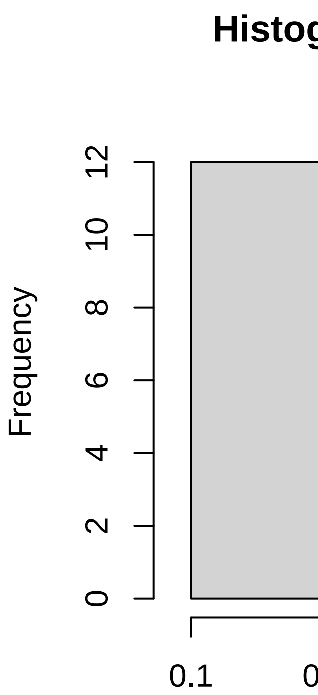
Postavljamo hipoteze: - H0: Postotci pobjeda putem nokauta jednaki su za muškarce i žene. - H1: Postotci pobjeda putem nokauta veći su za muškarce.

Razinu značajnosti α postavljamo na 0.1 kao i u prethodnim testovima.

```r
wilcox.test(male_ko_winners, female_ko_winners, alternative = "greater", conf.level = 0.9)
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  male_ko_winners and female_ko_winners
## W = 116214, p-value = 3.734e-10
## alternative hypothesis: true location shift is greater than 0
```

Na razini značajnosti $\alpha = 0.1$ možemo odbaciti H0 u korist H1 (postotak pobjeda putem nokauta veći je za muškarce).




```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  male_ko_winners_without_outliers and female_ko_winners_without_outliers
## W = 15008, p-value = 0.9836
## alternative hypothesis: true location shift is less than 0
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  male_ko_winners_without_outliers and female_ko_winners_without_outliers
## W = 15008, p-value = 0.01648
## alternative hypothesis: true location shift is greater than 0
```

Dodatni zadatak 3. - Razlikuje li se broj pobjeda i pobjeda putem knockout-a ovisno o stavu borca (stance)?

```
# Odredivanje broja pobjeda i broja pobjeda putem knockout-a za borce
total_wins = c()
total_wins_by_ko = c()
for (i in (1:nrow(fighter_details))) {
    fn = fighter_details[i, ]$fighter_name
    wins = subset(all, Winner == fn)
    wins_by_ko = subset(wins, win_by == "KO/TKO")
    total_wins = append(total_wins, nrow(wins))
    total_wins_by_ko = append(total_wins_by_ko, nrow(wins_by_ko))
}

# Dodavanje stupaca ukupnih pobjeda, ukupnih pobjeda putem knockout-a i ukupnih
# pobjeda bez knockout-a
fighter_details$total_wins = total_wins
fighter_details$total_wins_by_ko = total_wins_by_ko
fighter_details$total_wins_without_ko = total_wins - total_wins_by_ko

table(fighter_details$Stance)
```

```
##
##             Open Stance    Orthodox    Sideways    Southpaw      Switch
##         804           7        2163           3         493         126
```

Ignoriramo borce s nepoznatim stavom. Također ignoriramo borce sa stavom "Open Stance" i "Sideways" zbog male frekvencije. Ako je borac stava "Orthodox", onda je dešnjak. Ako je stava "Southpaw", onda je ljevak. Ako je "Switch", onda je ambidekstar.

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union

##
## Attaching package: 'data.table'

## The following objects are masked from 'package:dplyr':
##
##     between, first, last
```

```
stance_table
```

```
##      Stance total_wins_by_ko total_wins_without_ko
## 1: Orthodox             1408                  2999
## 2: Southpaw              384                   856
## 3:   Switch              100                   125
```

```
# Moramo maknuti Stance jer je u tablici to predstavljeno kao zavisna
# varijabla, a zapravo je nezavisna
stance_table = select(stance_table, -Stance)
```

Očekivane frekvencije su veće od 5 u svakoj ćeliji tablice. Stoga smijemo primjeniti test homogenosti. Postavljamo hipoteze: - H0: Postotak pobjeda putem nokauta jednak je za svaku od kategorija boraca prema stavu (ljevaci, dešnjaci i ambidekstri). - H1: Postotak pobjeda putem nokauta nije jednak za barem dvije od kategorija boraca prema stavu (ljevaci, dešnjaci i ambidekstri).

Za chisq.test nije dostupan argument conf_level, tako da ne postavljamo nikakvu razinu značajnosti kao argument testa. Ipak, odabiremo razinu značajnosti $\alpha = 0.05$.

```
chisq.test(stance_table, correct = FALSE)
```

```
##
##  Pearson's Chi-squared test
##
## data:  stance_table
## X-squared = 16.434, df = 2, p-value = 0.00027
```

Na odabranoj razini značajnosti možemo odbaciti H0 u korist H1 (udio pobjeda putem KO i pobjeda drugim načinima nije isti za sve kategorije Stance). Iz tablice *stance_table* možemo naslutiti da borci koji su ambidekstri imaju veći udio pobjeda putem KO.

4 zadatak - Možemo li iz zadanih obilježja predvidjeti pobjednika?

Za svaku borbu smo izračunali dob oba borca (Red i Blue) na dan borbe.

```
## Loading required package: timechange

##
## Attaching package: 'lubridate'

## The following objects are masked from 'package:data.table':
##
##     hour, isoweek, mday, minute, month, quarter, second, wday, week,
##     yday, year

## The following objects are masked from 'package:base':
##
##     date, intersect, setdiff, union
```

Određeni stupci unutar tablice svih borbi su u obliku "x of y" jer govore o tome koliko je udaraca borac obranio, primio i slično. Za podskup tih stupaca smo uzimali u obzir samo prvi broj x, jer nam on daje informaciju o razmijenjenim udarcima tijekom borbe. Drugi podskup tih stupaca opisuje općenitu preciznost borca, i za taj podskup stupaca smo izračunali omjer x/y (postotak).

Nakon toga smo odredili regresorske varijable. Zavisna varijabla je indikatorska varijabla u obliku vektora (označava pobjedu crvenog borca).

```
# Odabrane regresorske varijable i zavisna varijabla
selected_columns = c("R_KD", "B_KD", "R_SUB_ATT", "B_SUB_ATT", "R_REV", "B_REV",
    "TD_Avg.r", "SLpM.r", "SApM.r", "Sub_Avg.r", "TD_Avg.b", "SLpM.b", "SApM.b",
    "Sub_Avg.b", "Height_cm.b", "Height_cm.r", "Reach_cm.b", "Reach_cm.r", "Weight_kg.b",
    "Weight_kg.r", "red_age", "blue_age", "r_sig_str", "b_sig_str", "r_total_str",
    "b_total_str", "r_td", "b_td", "r_head", "b_head", "r_body", "b_body", "r_leg",
    "b_leg", "r_distance", "b_distance", "r_clinch", "b_clinch", "r_ground", "b_ground",
    "str_def.r", "str_acc.r", "td_acc.r", "td_def.r", "str_def.b", "str_acc.b", "td_acc.b",
    "td_def.b", "red_is_winner", "is_b_southpaw", "is_b_orthodox", "is_r_southpaw",
    "is_r_orthodox")
variables = selected_columns[selected_columns != "red_is_winner"]
```

```
library(tidyr)
# Iz seta podataka uzimamo samo odabrane regresorske varijable i zavisnu
```

```r
# varijablu
logreg_data = subset(all_for_logreg, select = selected_columns)
# Uzimamo samo retke koji nemaju NA vrijednosti unutar odabranih varijabli
logreg_data = logreg_data %>%
    drop_na()
```

```r
require(caret)
```

```
## Loading required package: caret
## Loading required package: ggplot2
## Loading required package: lattice
```

```r
# b je formula varijabla_1 + varijabla_2 + ..., pri čemu je varijabla_i unutar
# skupa odabranih regresorskih varijabli
b <- paste(variables, collapse = " + ")
logreg_mdl = glm(as.formula(paste("red_is_winner ~ ", b)), data = logreg_data, family = binomial())
summary(logreg_mdl)
```

```
##
## Call:
## glm(formula = as.formula(paste("red_is_winner ~ ", b)), family = binomial(),
##     data = logreg_data)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -3.7502  -0.4115   0.1432   0.4793   3.9856
##
## Coefficients: (4 not defined because of singularities)
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -2.315747   2.083947  -1.111 0.266469
## R_KD          1.615162   0.129801  12.443  < 2e-16 ***
## B_KD         -1.497188   0.116559 -12.845  < 2e-16 ***
## R_SUB_ATT     0.846789   0.074988  11.292  < 2e-16 ***
## B_SUB_ATT    -0.570666   0.068959  -8.275  < 2e-16 ***
## R_REV         0.332944   0.120130   2.772 0.005579 **
## B_REV        -0.584883   0.120491  -4.854 1.21e-06 ***
## TD_Avg.r     -0.165656   0.050094  -3.307 0.000943 ***
## SLpM.r       -0.242986   0.059511  -4.083 4.45e-05 ***
## SApM.r        0.109205   0.059600   1.832 0.066906 .
## Sub_Avg.r     0.042456   0.076657   0.554 0.579686
## TD_Avg.b      0.059693   0.051272   1.164 0.244326
## SLpM.b        0.080281   0.058936   1.362 0.173141
## SApM.b       -0.039535   0.056360  -0.701 0.483002
## Sub_Avg.b     0.118123   0.075815   1.558 0.119220
## Height_cm.b  -0.011844   0.013229  -0.895 0.370655
## Height_cm.r   0.008308   0.012877   0.645 0.518828
## Reach_cm.b    0.001010   0.010314   0.098 0.922021
## Reach_cm.r    0.012004   0.010020   1.198 0.230929
## Weight_kg.b   0.010779   0.010546   1.022 0.306725
## Weight_kg.r  -0.006530   0.010316  -0.633 0.526739
## red_age      -0.042532   0.012143  -3.503 0.000461 ***
## blue_age      0.017983   0.012749   1.410 0.158396
## r_sig_str     0.086270   0.013324   6.475 9.51e-11 ***
## b_sig_str    -0.093908   0.013507  -6.952 3.59e-12 ***
```

```
## r_total_str    0.013798   0.002766   4.988 6.11e-07 ***
## b_total_str   -0.002868   0.002696  -1.064 0.287503
## r_td           0.350693   0.042225   8.305  < 2e-16 ***
## b_td          -0.388208   0.041210  -9.420  < 2e-16 ***
## r_head         0.014486   0.007965   1.819 0.068955 .
## b_head        -0.025500   0.008057  -3.165 0.001551 **
## r_body        -0.015307   0.011333  -1.351 0.176814
## b_body        -0.014322   0.011892  -1.204 0.228449
## r_leg                NA         NA      NA       NA
## b_leg                NA         NA      NA       NA
## r_distance    -0.039667   0.010012  -3.962 7.44e-05 ***
## b_distance     0.050576   0.010486   4.823 1.41e-06 ***
## r_clinch      -0.035021   0.012530  -2.795 0.005189 **
## b_clinch       0.055289   0.013084   4.226 2.38e-05 ***
## r_ground             NA         NA      NA       NA
## b_ground             NA         NA      NA       NA
## str_def.r      1.026442   0.884551   1.160 0.245882
## str_acc.r      1.025007   0.822912   1.246 0.212917
## td_acc.r       0.436551   0.278385   1.568 0.116845
## td_def.r      -0.135485   0.276350  -0.490 0.623945
## str_def.b      0.898371   0.805421   1.115 0.264677
## str_acc.b     -0.525559   0.770376  -0.682 0.495106
## td_acc.b       0.527283   0.270049   1.953 0.050873 .
## td_def.b      -0.352784   0.240572  -1.466 0.142529
## is_b_southpaw  0.110691   0.246610   0.449 0.653539
## is_b_orthodox  0.011043   0.231438   0.048 0.961944
## is_r_southpaw  0.215440   0.277156   0.777 0.436968
## is_r_orthodox  0.064542   0.262283   0.246 0.805621
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 6505.0  on 4894  degrees of freedom
## Residual deviance: 3154.8  on 4846  degrees of freedom
## AIC: 3252.8
##
## Number of Fisher Scoring iterations: 6
```

Iz ispisa uočavamo da su neki od regresora međusobno zavisni (NA vrijednosti). U ispisu su označeni statistički signifikantni regresori.

Na tri različita načina evaluirat ćemo kvalitetu dobivenog modela.

Računamo R^2 koji govori o tome koliko je procjenjeni model blizu ili daleko od nul-modela (što je R^2 bliži 1, to je model bolji).

```
# Računanje Rsq
Rsq = 1 - logreg_mdl$deviance/logreg_mdl$null.deviance
Rsq
```

```
## [1] 0.5150178
```

Izrađujemo matricu zabune.

```
# Izrada confusion matrix-a
yhat <- logreg_mdl$fitted.values >= 0.5
```

```r
tab <- table(logreg_data$red_is_winner, yhat)

tab
```

```
##    yhat
##     FALSE TRUE
##   0  1527  337
##   1   273 2758
```

Iz matrice zabune možemo zaključiti da model dobro predviđa ishod borbe (borbe u kojima crveni borac nije pobjednik su označene kao takve, i obrnuto).

```r
accuracy = sum(diag(tab))/sum(tab)
precision = tab[2, 2]/sum(tab[, 2])
recall = tab[2, 2]/sum(tab[2, ])
specificity = tab[1, 1]/sum(tab[, 1])

accuracy
```

```
## [1] 0.875383
```

```r
precision
```

```
## [1] 0.8911147
```

```r
recall
```

```
## [1] 0.9099307
```

```r
specificity
```

```
## [1] 0.8483333
```

Zbog visokih vrijednosti izračunatih varijabli (točnost, preciznost, odziv i specifičnost) možemo zaključiti da je model kvalitetan.

Model bez linearno zavisnih ili neznačajnih regresora

```r
# Izbacivanje nesignifikantnih varijabli
significant_variables = c("R_KD", "B_KD", "R_SUB_ATT", "B_SUB_ATT", "R_REV", "B_REV",
    "TD_Avg.r", "red_age", "r_sig_str", "b_sig_str", "r_total_str", "r_td", "b_td",
    "r_head", "b_head", "r_distance", "b_distance", "r_clinch", "b_clinch", "td_acc.b")

b <- paste(significant_variables, collapse = " + ")
logreg_mdl_reduced = glm(as.formula(paste("red_is_winner ~ ", b)), data = logreg_data,
    family = binomial())
summary(logreg_mdl_reduced)
```

```
##
## Call:
## glm(formula = as.formula(paste("red_is_winner ~ ", b)), family = binomial(),
##     data = logreg_data)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -3.6433  -0.4280   0.1465   0.4861   4.0328
##
## Coefficients:
```

```
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept)  0.962231   0.368571   2.611  0.00904 **
## R_KD         1.607436   0.128391  12.520  < 2e-16 ***
## B_KD        -1.508489   0.112876 -13.364  < 2e-16 ***
## R_SUB_ATT    0.862154   0.068966  12.501  < 2e-16 ***
## B_SUB_ATT   -0.542844   0.061487  -8.829  < 2e-16 ***
## R_REV        0.345064   0.118854   2.903  0.00369 **
## B_REV       -0.604762   0.118980  -5.083 3.72e-07 ***
## TD_Avg.r    -0.120331   0.043399  -2.773  0.00556 **
## red_age     -0.026947   0.011107  -2.426  0.01526 *
## r_sig_str    0.072030   0.011583   6.219 5.01e-10 ***
## b_sig_str   -0.101973   0.010755  -9.482  < 2e-16 ***
## r_total_str  0.012599   0.002618   4.812 1.49e-06 ***
## r_td         0.340061   0.040379   8.422  < 2e-16 ***
## b_td        -0.376136   0.035837 -10.496  < 2e-16 ***
## r_head       0.025316   0.006281   4.031 5.56e-05 ***
## b_head      -0.020417   0.006350  -3.215  0.00130 **
## r_distance  -0.038536   0.009728  -3.961 7.46e-05 ***
## b_distance   0.051120   0.009804   5.214 1.85e-07 ***
## r_clinch    -0.037243   0.012331  -3.020  0.00253 **
## b_clinch     0.053164   0.012694   4.188 2.81e-05 ***
## td_acc.b     0.680129   0.242015   2.810  0.00495 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 6505  on 4894  degrees of freedom
## Residual deviance: 3210  on 4874  degrees of freedom
## AIC: 3252
##
## Number of Fisher Scoring iterations: 6
```

Kao i za prethodni model, računamo iste mjere kvalitete (R^2, točnost, preciznost, odziv i specifičnost).

```r
Rsq = 1 - logreg_mdl_reduced$deviance/logreg_mdl_reduced$null.deviance
Rsq
```

```
## [1] 0.5065386
```

```r
yhat <- logreg_mdl_reduced$fitted.values >= 0.5
tab <- table(logreg_data$red_is_winner, yhat)

tab
```

```
##    yhat
##     FALSE TRUE
##   0  1519  345
##   1   268 2763
```

```r
accuracy = sum(diag(tab))/sum(tab)
precision = tab[2, 2]/sum(tab[, 2])
recall = tab[2, 2]/sum(tab[2, ])
specificity = tab[1, 1]/sum(tab[, 1])

accuracy
```

```
## [1] 0.8747702
```

```
precision
```

```
## [1] 0.8889961
```

```
recall
```

```
## [1] 0.9115803
```

```
specificity
```

```
## [1] 0.850028
```

Usporedba originalnog i reduciranog modela

Za usporedbu modela koristit ćemo ANOVA-u. Postavljamo hipoteze: - H0: Modeli su jednake kvalitete - H1: Originalni model je bolji od reduciranog

```
# Usporedba dva modela
anova(logreg_mdl, logreg_mdl_reduced, test = "LRT")
```

```
## Analysis of Deviance Table
##
## Model 1: red_is_winner ~ R_KD + B_KD + R_SUB_ATT + B_SUB_ATT + R_REV +
##     B_REV + TD_Avg.r + SLpM.r + SApM.r + Sub_Avg.r + TD_Avg.b +
##     SLpM.b + SApM.b + Sub_Avg.b + Height_cm.b + Height_cm.r +
##     Reach_cm.b + Reach_cm.r + Weight_kg.b + Weight_kg.r + red_age +
##     blue_age + r_sig_str + b_sig_str + r_total_str + b_total_str +
##     r_td + b_td + r_head + b_head + r_body + b_body + r_leg +
##     b_leg + r_distance + b_distance + r_clinch + b_clinch + r_ground +
##     b_ground + str_def.r + str_acc.r + td_acc.r + td_def.r +
##     str_def.b + str_acc.b + td_acc.b + td_def.b + is_b_southpaw +
##     is_b_orthodox + is_r_southpaw + is_r_orthodox
## Model 2: red_is_winner ~ R_KD + B_KD + R_SUB_ATT + B_SUB_ATT + R_REV +
##     B_REV + TD_Avg.r + red_age + r_sig_str + b_sig_str + r_total_str +
##     r_td + b_td + r_head + b_head + r_distance + b_distance +
##     r_clinch + b_clinch + td_acc.b
##   Resid. Df Resid. Dev  Df Deviance Pr(>Chi)
## 1      4846     3154.8
## 2      4874     3210.0 -28  -55.157 0.001627 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Sa razinom značajnosti $\alpha = 0.05$ zaključujemo da možemo odbaciti H0 u korist H1 (originalni model bolji je od reduciranog).

Model sa apriornim podacima

```
fighter_details_variables = c("TD_Avg.r", "SLpM.r", "SApM.r", "Sub_Avg.r", "TD_Avg.b",
    "SLpM.b", "SApM.b", "Sub_Avg.b", "Height_cm.b", "Height_cm.r", "Reach_cm.b",
    "Reach_cm.r", "Weight_kg.b", "Weight_kg.r", "red_age", "blue_age", "str_def.r",
    "str_acc.r", "td_acc.r", "td_def.r", "str_def.b", "str_acc.b", "td_acc.b", "td_def.b",
    "red_is_winner", "is_b_southpaw", "is_b_orthodox", "is_r_southpaw", "is_r_orthodox")
logreg_fighters_data = subset(logreg_data, select = fighter_details_variables)
fighter_details_variables = fighter_details_variables[fighter_details_variables !=
    "red_is_winner"]
```

```r
b <- paste(fighter_details_variables, collapse = " + ")
logreg_mdl_fighter_details = glm(as.formula(paste("red_is_winner ~ ", b)), data = logreg_fighters_data,
    family = binomial())
summary(logreg_mdl_fighter_details)
```

```
##
## Call:
## glm(formula = as.formula(paste("red_is_winner ~ ", b)), family = binomial(),
##     data = logreg_fighters_data)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.5911  -1.1276   0.6372   0.9376   2.5427
##
## Coefficients:
##                Estimate Std. Error z value Pr(>|z|)
## (Intercept)    0.362263   1.470762   0.246 0.805442
## TD_Avg.r       0.082014   0.031043   2.642 0.008243 **
## SLpM.r         0.193547   0.041759   4.635 3.57e-06 ***
## SApM.r        -0.236117   0.046166  -5.115 3.15e-07 ***
## Sub_Avg.r      0.228914   0.053854   4.251 2.13e-05 ***
## TD_Avg.b      -0.135603   0.030649  -4.424 9.67e-06 ***
## SLpM.b        -0.393796   0.040807  -9.650  < 2e-16 ***
## SApM.b         0.290459   0.042341   6.860 6.89e-12 ***
## Sub_Avg.b     -0.020913   0.050196  -0.417 0.676955
## Height_cm.b    0.003686   0.009000   0.410 0.682136
## Height_cm.r   -0.018386   0.008944  -2.056 0.039817 *
## Reach_cm.b    -0.010076   0.006999  -1.440 0.149995
## Reach_cm.r     0.015135   0.007032   2.152 0.031382 *
## Weight_kg.b   -0.006954   0.007143  -0.973 0.330337
## Weight_kg.r    0.018584   0.007034   2.642 0.008240 **
## red_age       -0.070837   0.008392  -8.441  < 2e-16 ***
## blue_age       0.035646   0.008532   4.178 2.94e-05 ***
## str_def.r      2.573977   0.627867   4.100 4.14e-05 ***
## str_acc.r      1.311565   0.568228   2.308 0.020990 *
## td_acc.r       0.246586   0.199762   1.234 0.217052
## td_def.r       0.642828   0.193815   3.317 0.000911 ***
## str_def.b      0.009585   0.573514   0.017 0.986666
## str_acc.b     -0.089157   0.533090  -0.167 0.867177
## td_acc.b       0.727728   0.185291   3.927 8.58e-05 ***
## td_def.b      -0.958857   0.174279  -5.502 3.76e-08 ***
## is_b_southpaw  0.131983   0.173821   0.759 0.447669
## is_b_orthodox  0.201698   0.163164   1.236 0.216397
## is_r_southpaw  0.214007   0.196056   1.092 0.275027
## is_r_orthodox  0.035178   0.186356   0.189 0.850274
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 6505.0  on 4894  degrees of freedom
## Residual deviance: 5812.6  on 4866  degrees of freedom
## AIC: 5870.6
##
```

```
## Number of Fisher Scoring iterations: 4
```

```r
# Računanje Rsq
Rsq = 1 - logreg_mdl_fighter_details$deviance/logreg_mdl_fighter_details$null.deviance
Rsq
```

```
## [1] 0.1064381
```

```r
yhat <- logreg_mdl_fighter_details$fitted.values >= 0.5
tab <- table(logreg_fighters_data$red_is_winner, yhat)

tab
```

```
##    yhat
##     FALSE TRUE
##   0   754 1110
##   1   437 2594
```

```r
accuracy = sum(diag(tab))/sum(tab)
precision = tab[2, 2]/sum(tab[, 2])
recall = tab[2, 2]/sum(tab[2, ])
specificity = tab[1, 1]/sum(tab[, 1])

sprintf("Accuracy: %.3f", accuracy)
```

```
## [1] "Accuracy: 0.684"
```

```r
sprintf("Precision: %.3f", precision)
```

```
## [1] "Precision: 0.700"
```

```r
sprintf("Recall: %.3f", recall)
```

```
## [1] "Recall: 0.856"
```

```r
sprintf("Specificity: %.3f", specificity)
```

```
## [1] "Specificity: 0.633"
```