ATP Data Analysis

2024-01-10

Instalacija potrebnih paketa.

```
# install.packages("dplyr")
# install.packages("lubridate")
# install.packages("ggplot2")
# install.packages("caret")
```

Učitavanje biblioteka.

```
library(dplyr)
```

```
##
## 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
```

```
library(lubridate)
```

```
##
## Attaching package: 'lubridate'

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

```
library(ggplot2)
library(caret)
```

```
## Loading required package: lattice
```

```
library(nortest)
```

Učitavanje i opis podataka

```r
all_matches <- data.frame()
for (year in 1991:2023) {
  file_name <- paste0("dataset/atp_matches_", year, ".csv")
  matches_year <- read.csv(file_name, stringsAsFactors = FALSE)
  all_matches <- rbind(all_matches, matches_year)
}

print(head(all_matches))
```

```
##   tourney_id tourney_name surface draw_size tourney_level tourney_date
## 1   1991-339     Adelaide    Hard        32             A     19901231
## 2   1991-339     Adelaide    Hard        32             A     19901231
## 3   1991-339     Adelaide    Hard        32             A     19901231
## 4   1991-339     Adelaide    Hard        32             A     19901231
## 5   1991-339     Adelaide    Hard        32             A     19901231
## 6   1991-339     Adelaide    Hard        32             A     19901231
##   match_num winner_id winner_seed winner_entry          winner_name winner_hand
## 1         1    101723          NA                    Magnus Larsson           R
## 2         2    100946          NA            Q Slobodan Zivojinovic           R
## 3         3    101234          NA                     Patrik Kuhnen           R
## 4         4    101889           8                   Todd Woodbridge           R
## 5         5    101274          NA                     Udo Riglewski           R
## 6         6    102148          NA                   Fabrice Santoro           R
##   winner_ht winner_ioc winner_age loser_id loser_seed loser_entry
## 1       193        SWE       20.7   101414          1
## 2       198        YUG       27.4   101256         NA
## 3       190        GER       24.8   101421         NA
## 4       178        AUS       19.7   101703         NA
## 5       185        GER       24.4   101843          4
## 6       178        FRA       18.0   101285         NA
##          loser_name loser_hand loser_ht loser_ioc loser_age          score
## 1     Boris Becker          R      190       GER      23.1 6-4 3-6 7-6(2)
## 2   Mark Kratzmann          L      178       AUS      24.6 6-3 3-6 7-6(6)
## 3   Veli Paloheimo          R      183       FIN      23.0        6-0 6-4
## 4  Guillaume Raoux          R      180       FRA      20.8     7-6(2) 6-1
## 5   Sergi Bruguera          R      188       ESP      19.9        7-5 6-3
## 6 Thierry Champion          R      183       FRA      24.3        6-2 6-3
##   best_of round minutes w_ace w_df w_svpt w_1stIn w_1stWon w_2ndWon w_SvGms
## 1       3   R32     130     6    2     96      55       39       25      15
## 2       3   R32     119    19    4    101      56       45       25      15
## 3       3   R32      71     6    1     54      31       24       13       8
## 4       3   R32      85     2    0     60      40       30       14       9
## 5       3   R32      90     4    2     72      40       33       14      10
## 6       3   R32      88     2    1     61      45       32        4       8
##   w_bpSaved w_bpFaced l_ace l_df l_svpt l_1stIn l_1stWon l_2ndWon l_SvGms
## 1         2         4     8    3     95      62       44       23      16
## 2         9        10     8    2     84      41       35       27      15
## 3         1         1     2    2     60      37       22        6       8
## 4         3         3     3    3     74      45       30       11      10
## 5         7         8     2    2     77      41       28       15      11
## 6         7         9     1    0     62      45       20        8       9
##   l_bpSaved l_bpFaced winner_rank winner_rank_points loser_rank
## 1         6         8          56                 NA          2
## 2         1         2       304                 NA         75
## 3         4         8        82                 NA         69
## 4         5         8        50                 NA         84
## 5         4         8        88                 NA         28
## 6        10        16        62                 NA         59
##   loser_rank_points
## 1                NA
## 2                NA
## 3                NA
## 4                NA
## 5                NA
## 6                NA
```

TODO Opis ispisa

```
print(names(all_matches))
```

```
##  [1] "tourney_id"         "tourney_name"       "surface"           
##  [4] "draw_size"          "tourney_level"      "tourney_date"      
##  [7] "match_num"          "winner_id"          "winner_seed"       
## [10] "winner_entry"       "winner_name"        "winner_hand"       
## [13] "winner_ht"          "winner_ioc"         "winner_age"        
## [16] "loser_id"           "loser_seed"         "loser_entry"       
## [19] "loser_name"         "loser_hand"         "loser_ht"          
## [22] "loser_ioc"          "loser_age"          "score"             
## [25] "best_of"            "round"              "minutes"           
## [28] "w_ace"              "w_df"               "w_svpt"            
## [31] "w_1stIn"            "w_1stWon"           "w_2ndWon"          
## [34] "w_SvGms"            "w_bpSaved"          "w_bpFaced"         
## [37] "l_ace"              "l_df"               "l_svpt"            
## [40] "l_1stIn"            "l_1stWon"           "l_2ndWon"          
## [43] "l_SvGms"            "l_bpSaved"          "l_bpFaced"         
## [46] "winner_rank"        "winner_rank_points" "loser_rank"        
## [49] "loser_rank_points"
```

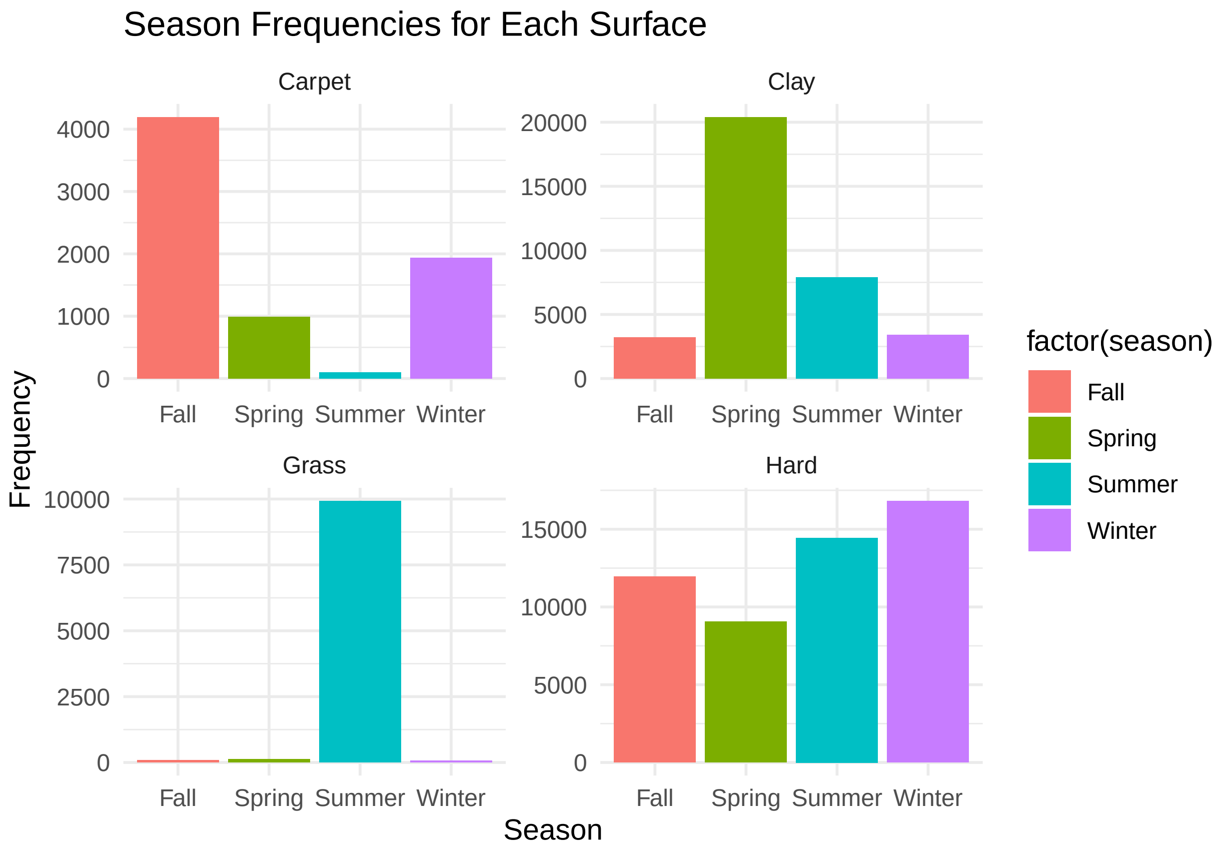
TODO Opis ispisa

```
print(summary(all_matches))
```

```
##   tourney_id        tourney_name         surface            draw_size     
##  Length:104682      Length:104682      Length:104682      Min.   :  2.00  
##  Class :character   Class :character   Class :character   1st Qu.: 32.00  
##  Mode  :character   Mode  :character   Mode  :character   Median : 32.00  
##                                                           Mean   : 53.52  
##                                                           3rd Qu.: 64.00  
##                                                           Max.   :128.00  
##                                                                           
##  tourney_level       tourney_date        match_num         winner_id     
##  Length:104682      Min.   :19901231   Min.   :   1.00   Min.   :100284  
##  Class :character   1st Qu.:19971006   1st Qu.:  10.00   1st Qu.:102148  
##  Mode  :character   Median :20050815   Median :  24.00   Median :103602  
##                     Mean   :20058134   Mean   :  72.47   Mean   :106703  
##                        3rd Qu.:20140224   3rd Qu.:  73.00   3rd Qu.:104797
##                        Max.   :20230828   Max.   :1701.00   Max.   :211468
##
##   winner_seed    winner_entry       winner_name        winner_hand
##  Min.   : 1.00   Length:104682      Length:104682      Length:104682
##  1st Qu.: 3.00   Class :character   Class :character   Class :character
##  Median : 5.00   Mode  :character   Mode  :character   Mode  :character
##  Mean   : 6.92
##  3rd Qu.: 8.00
##  Max.   :35.00
##  NA's   :62282
##    winner_ht      winner_ioc          winner_age       loser_id
##  Min.   :160.0   Length:104682      Min.   :14.30   Min.   :100282
##  1st Qu.:180.0   Class :character   1st Qu.:23.00   1st Qu.:102154
##  Median :185.0   Mode  :character   Median :25.50   Median :103566
##  Mean   :185.7                      Mean   :25.77   Mean   :106814
##  3rd Qu.:190.0                      3rd Qu.:28.30   3rd Qu.:104919
##  Max.   :211.0                      Max.   :42.70   Max.   :212041
##  NA's   :2454                       NA's   :5
##    loser_seed    loser_entry         loser_name         loser_hand
##  Min.   : 1.00   Length:104682      Length:104682      Length:104682
##  1st Qu.: 4.00   Class :character   Class :character   Class :character
##  Median : 6.00   Mode  :character   Mode  :character   Mode  :character
##  Mean   : 8.29
##  3rd Qu.:11.00
##  Max.   :35.00
##  NA's   :81382
##     loser_ht      loser_ioc          loser_age       score
##  Min.   :160.0   Length:104682      Min.   :14.50   Length:104682
##  1st Qu.:180.0   Class :character   1st Qu.:23.00   Class :character
##  Median :185.0   Mode  :character   Median :25.70   Mode  :character
##  Mean   :185.2                      Mean   :25.88
##  3rd Qu.:190.0                      3rd Qu.:28.50
##  Max.   :211.0                      Max.   :46.00
##  NA's   :4855                       NA's   :18
##     best_of         round              minutes          w_ace
##  Min.   :3.000   Length:104682      Min.   :   0.0   Min.   :  0.000
##  1st Qu.:3.000   Class :character   1st Qu.:  75.0   1st Qu.:  3.000
##  Median :3.000   Mode  :character   Median :  96.0   Median :  5.000
##  Mean   :3.441                      Mean   : 103.8   Mean   :  6.526
##  3rd Qu.:3.000                      3rd Qu.: 125.0   3rd Qu.:  9.000
##  Max.   :5.000                      Max.   :1146.0   Max.   :113.000
##                                     NA's   :13036    NA's   :10207
##       w_df           w_svpt          w_1stIn          w_1stWon
##  Min.   : 0.000   Min.   :  0.00   Min.   :  0.00   Min.   :  0.00
##  1st Qu.: 1.000   1st Qu.: 56.00   1st Qu.: 34.00   1st Qu.: 26.00
##  Median : 2.000   Median : 73.00   Median : 44.00   Median : 33.00
##  Mean   : 2.734   Mean   : 78.13   Mean   : 47.66   Mean   : 35.93
##  3rd Qu.: 4.000   3rd Qu.: 94.00   3rd Qu.: 58.00   3rd Qu.: 43.00
##  Max.   :26.000   Max.   :491.00   Max.   :361.00   Max.   :292.00
##  NA's   :10207    NA's   :10207    NA's   :10207    NA's   :10207
##     w_2ndWon        w_SvGms        w_bpSaved        w_bpFaced
##  Min.   : 0.00   Min.   : 0.00   Min.   : 0.000   Min.   : 0.000
##  1st Qu.:12.00   1st Qu.: 9.00   1st Qu.: 1.000   1st Qu.: 2.000
##  Median :16.00   Median :11.00   Median : 3.000   Median : 4.000  
##  Mean   :16.73   Mean   :12.41   Mean   : 3.526   Mean   : 5.164  
##  3rd Qu.:21.00   3rd Qu.:15.00   3rd Qu.: 5.000   3rd Qu.: 7.000  
##  Max.   :82.00   Max.   :90.00   Max.   :24.000   Max.   :34.000  
##  NA's   :10207   NA's   :10206   NA's   :10207    NA's   :10207   
##      l_ace              l_df            l_svpt          l_1stIn      
##  Min.   :  0.000   Min.   : 0.000   Min.   :  0.00   Min.   :  0.00  
##  1st Qu.:  2.000   1st Qu.: 2.000   1st Qu.: 59.00   1st Qu.: 34.00  
##  Median :  4.000   Median : 3.000   Median : 76.00   Median : 45.00  
##  Mean   :  4.841   Mean   : 3.485   Mean   : 80.97   Mean   : 48.09  
##  3rd Qu.:  7.000   3rd Qu.: 5.000   3rd Qu.: 97.00   3rd Qu.: 58.00  
##  Max.   :103.000   Max.   :26.000   Max.   :489.00   Max.   :328.00  
##  NA's   :10207     NA's   :10207    NA's   :10207    NA's   :10207   
##     l_1stWon         l_2ndWon         l_SvGms        l_bpSaved     
##  Min.   :  0.00   Min.   :  0.00   Min.   : 0.00   Min.   :-6.000  
##  1st Qu.: 22.00   1st Qu.: 10.00   1st Qu.: 9.00   1st Qu.: 2.000  
##  Median : 30.00   Median : 14.00   Median :11.00   Median : 4.000  
##  Mean   : 31.95   Mean   : 14.98   Mean   :12.21   Mean   : 4.813  
##  3rd Qu.: 40.00   3rd Qu.: 19.00   3rd Qu.:15.00   3rd Qu.: 7.000  
##  Max.   :284.00   Max.   :101.00   Max.   :91.00   Max.   :28.000  
##  NA's   :10207    NA's   :10207    NA's   :10206   NA's   :10207   
##    l_bpFaced      winner_rank      winner_rank_points   loser_rank    
##  Min.   : 0.00   Min.   :   1.00   Min.   :    1      Min.   :   1.0  
##  1st Qu.: 6.00   1st Qu.:  18.00   1st Qu.:  529      1st Qu.:  37.0  
##  Median : 8.00   Median :  46.00   Median :  880      Median :  70.0  
##  Mean   : 8.74   Mean   :  80.66   Mean   : 1429      Mean   : 119.1  
##  3rd Qu.:11.00   3rd Qu.:  89.00   3rd Qu.: 1598      3rd Qu.: 119.0  
##  Max.   :38.00   Max.   :2101.00   Max.   :16950      Max.   :2159.0  
##  NA's   :10207   NA's   :1189      NA's   :2177       NA's   :2536    
##  loser_rank_points
##  Min.   :    1.0  
##  1st Qu.:  395.0  
##  Median :  658.0  
##  Mean   :  895.6  
##  3rd Qu.: 1040.0  
##  Max.   :16950.0  
##  NA's   :3519
```

TODO Opis ispisa, možda uzet summary samo za neke značajke

Zadatak 1. Kakva je distribucija mečeva na specifičnim podlogama u različitim godišnjim dobima?

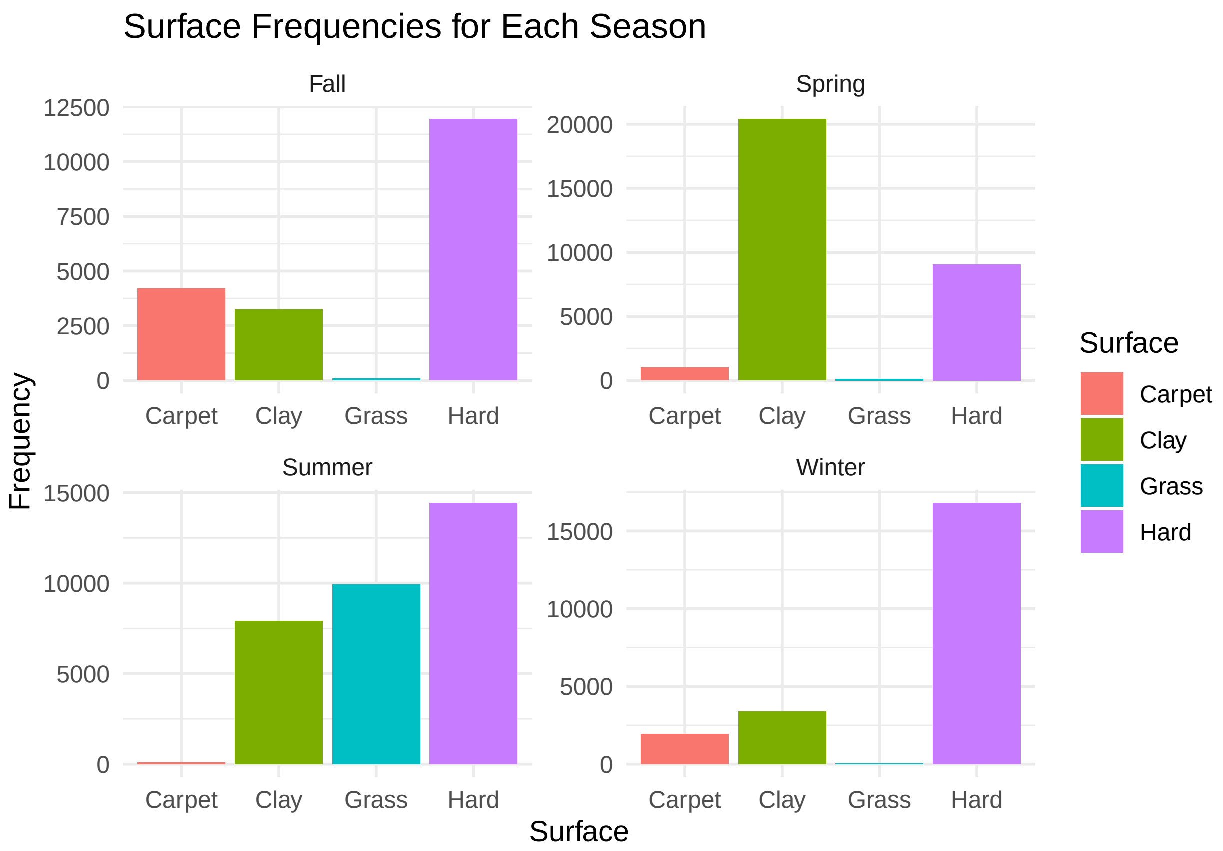


U prvom histogramu prikazana je raspodjela teniskih mečeva prema godišnjim dobima na podlozi od tepiha. Podloga od tepiha najmanje je korištena podloga za igranje mečeva. Najčešće se podloga od tepiha koristila u jesen, dosta rjeđe zimi, zatim na proljeće, a najmanje se mečeva na podlozi od tepiha igra na ljeto.

Sljedeći histogram predstavlja raspodjelu mečeva prema godišnjim dobima na zemljanoj podlozi. Mečevi na zemlji najčešće se igraju u proljetnom dijelu sezone. Dosta manje mečeva igra se na ljeto zatim otprilike podjednako na jesen i zimi.

Treći histogram opisuje distribuciju teniskih mečeva prema godišnjim dobima na travi. Teniski mečevi na travi igraju se uglavnom ljeti, a svega nekoliko mečeva igra se u preostalim godišnjim dobima.

U posljednjem histogramu promatrana je raspodjela mečeva prema godišnjim dobima na tvrdoj podlozi. Sveukupno najviše mečeva igra se na tvrdoj podlozi te je raspodjela prema godišnjim dobima manje izražena nego kod drugih podloga. Najviše mečeva na tvrdoj podlozi održava se zimi, zatim u ljeto pa na jesen te najmanje u proljetnom dijelu sezone.



Prvi histogram prikazuje raspodjelu mečeva prema podlogama u jesen. Uvjerljivo najviše mečeva u jesen održava se na tvrdoj podlozi. Dosta manje mečeva igra se na podlozi od tepiha, a nešto malo manje na zemlji. Najmanje mečeva u jesenskom dijelu sezone igra se na travi.

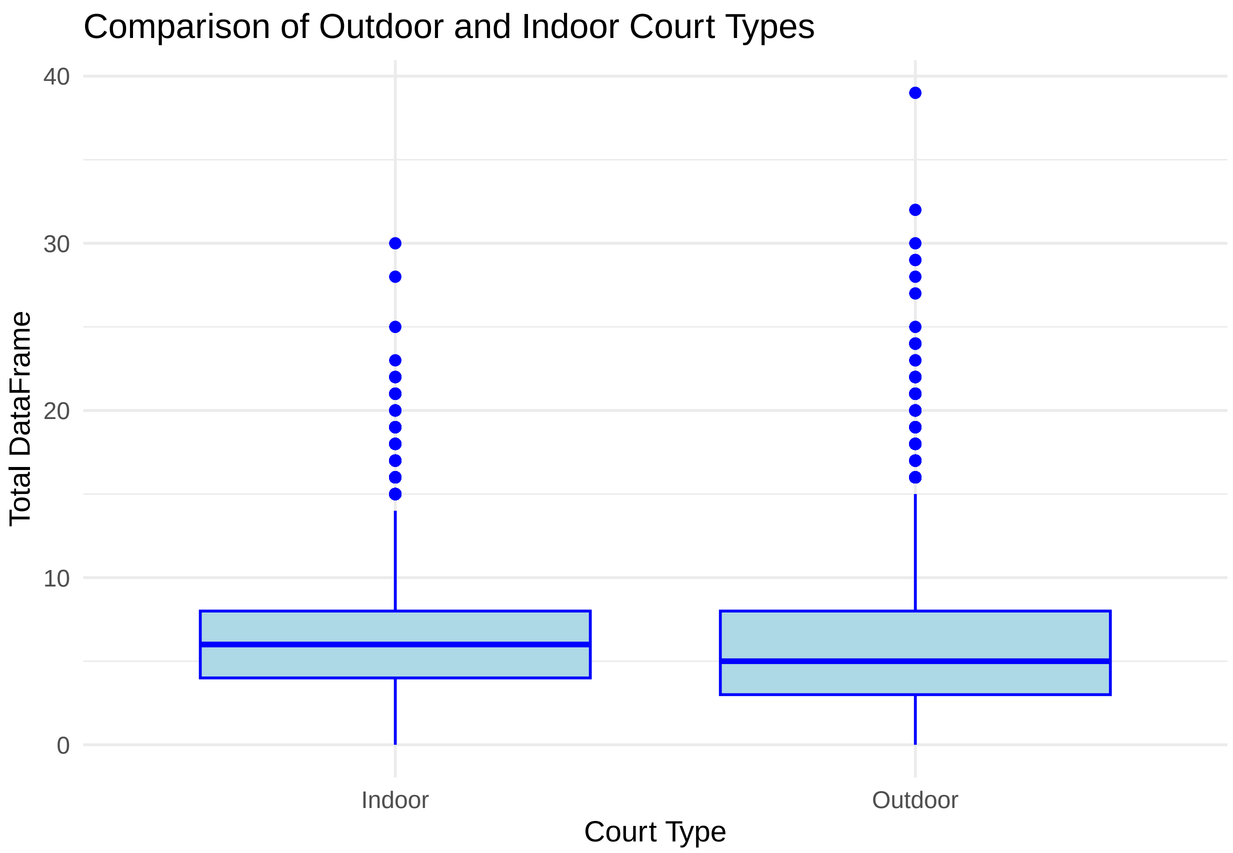
Idući histogram prikazuje raspodjelu mečeva prema podlogama u proljeće. U proljetnom dijelu sezone uvjerljivo najviše teniskih mečeva igra se na podlozi od zemlje. Više od dvostruko manje mečeva održava se na tvrdoj podlozi. Jako malo mečeva održava se na podlozi od tepiha, a još manje na travi.

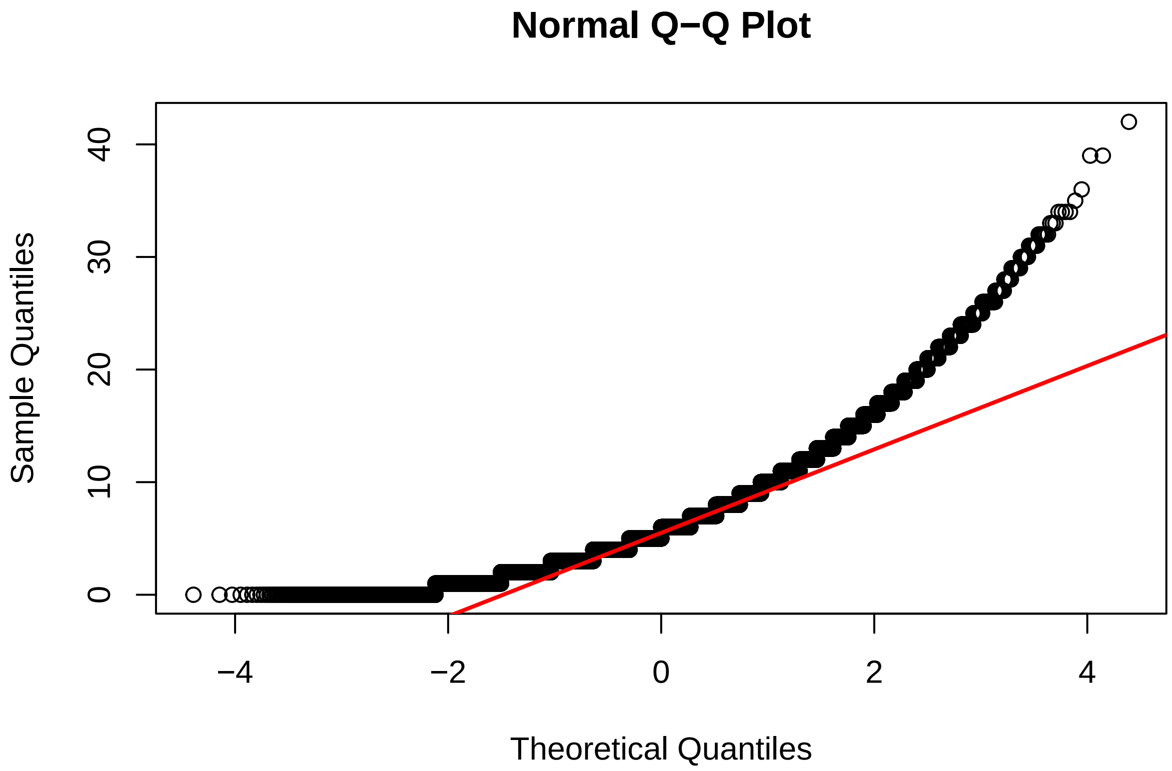
U trećem histogramu promatramo raspodjelu mečeva prema podlogama tijekom ljeta. Najviše mečeva održava se na tvrdoj podlozi, zatim na travi pa na podlozi od zemlje. Svega nekoliko mečeva igra se na podlozi od tepiha.

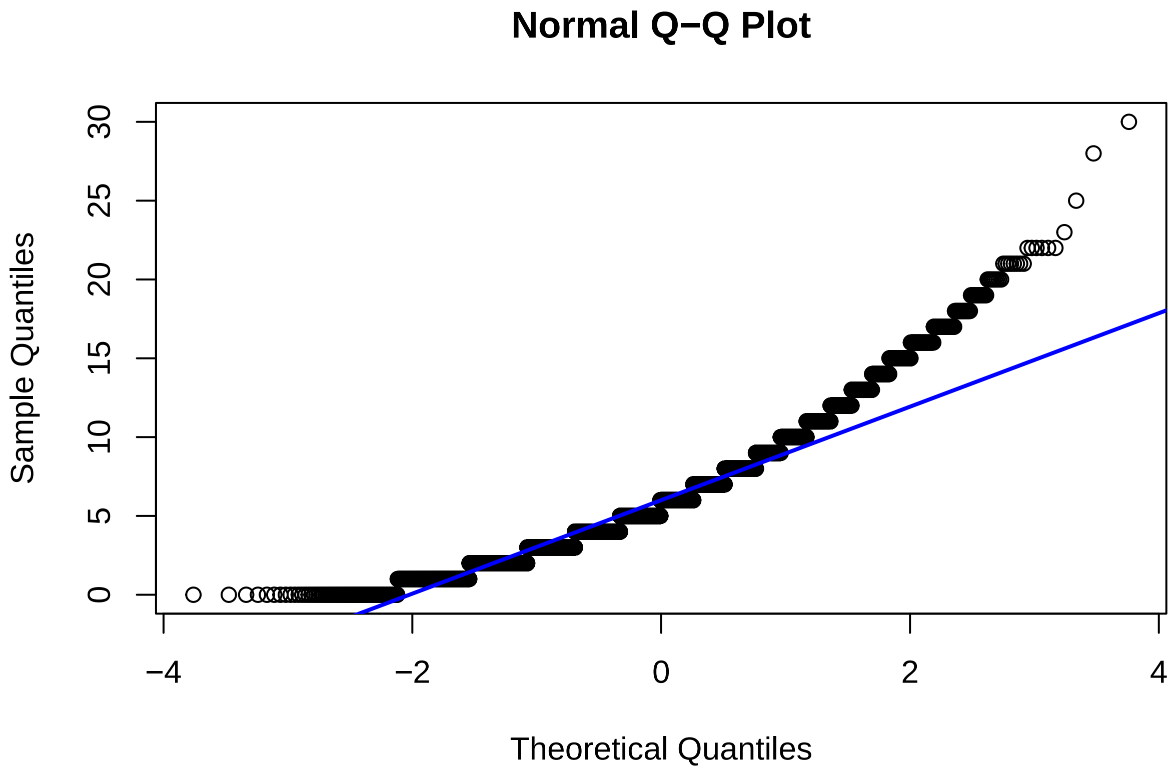
Zadnji histogram opisuje raspodjelu mečeva prema podlogama zimi. Tijekom zime prednjače mečevi na tvrdoj podlozi. Dosta manje mečeva igra se na zemlji, zatim na podlozi od tepiha te najmanje na travi.

Zadatak 2. Postoji li značajna razlika u prosječnom broju dvostrukih pogrešaka između mečeva odigranih na otvorenom u odnosu na mečeve odigrane na zatvorenom terenu?

Na početku provjeravamo normalnost podataka, najprije pomoću boxplot i Q-Q grafova.


Comparison of Outdoor and Indoor Court Types
40
30
20
10
0
Total DataFrame
Indoor
Outdoor
Court Type


Normal Q−Q Plot
Sample Quantiles
0
10
20
30
40
Theoretical Quantiles
−4
−2
0
2
4



Zatim provodimo Lilliefors test:

```
##
##  Lilliefors (Kolmogorov-Smirnov) normality test
##
## data:  open_surface_data
## D = 0.12974, p-value < 2.2e-16
```

```
##
##  Lilliefors (Kolmogorov-Smirnov) normality test
##
## data:  closed_surface_data
## D = 0.12216, p-value < 2.2e-16
```

Za oba skupa podataka (otvoreni teren i zatvoreni teren), rezultati testova normalnosti (Lilliefors test) pokazuju da podaci nisu normalno distribuirani (p-vrijednosti su manje od 0.05) što se moglo zaključiti i iz grafova. To znači da distribucija podataka odstupa od normalne distribucije.

Onda provodimo F-test za provjeru homogenosti varijanci:

```
##
##  F test to compare two variances
##
## data:  open_surface_data and closed_surface_data
## F = 1.1441, num df = 88596, denom df = 5877, p-value = 4.316e-12
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  1.101871 1.187308
## sample estimates:
## ratio of variances
##           1.144146
```

F-test za usporedbu varijanci pokazuje da nema značajne razlike u varijancama između otvorenog terena i zatvorenog terena (p-vrijednost = 4.316e-12). Ovaj rezultat ukazuje na homogenost varijanci između ova dva skupa podataka.

Nakon toga provodimo Wilcoxon rang-sum test:

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  open_surface_data and closed_surface_data
## W = 258377269, p-value = 0.3191
## alternative hypothesis: true location shift is not equal to 0
```

Wilcoxon rang-sum test ne pokazuje značajnu razliku u srednjim vrijednostima (medijanama) između otvorenog i zatvorenog terena (p-vrijednost = 0.3191).

Na kraju provodimo t-test za uparene uzorke:

```
##
##  Two Sample t-test
##
## data:  open_surface_data and closed_surface_data
## t = 0.8201, df = 94473, p-value = 0.4122
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.06059204  0.14777857
## sample estimates:
## mean of x mean of y
##  6.221035  6.177441
```

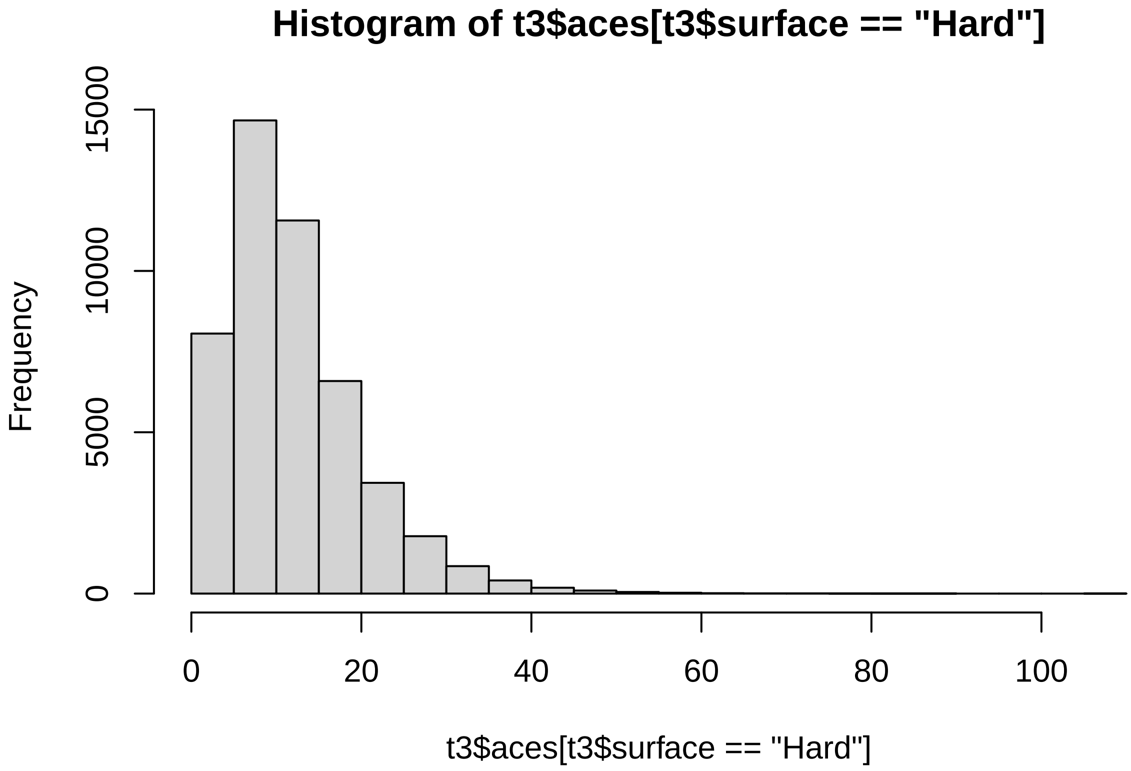
Two Sample t-test također ne pokazuje značajnu razliku između srednjih vrijednosti otvorenog terena i zatvorenog terena (p-vrijednost = 0.4122). 95% interval pouzdanosti za razliku u srednjim vrijednostima uključuje nulu, što dodatno potvrđuje nedostatak značajne razlike.

Na temelju ovih rezultata, možemo zaključiti da nema značajne razlike u prosječnom broju dvostrukih pogrešaka između mečeva odigranih na otvorenom terenu i mečeva odigranih na zatvorenom terenu.

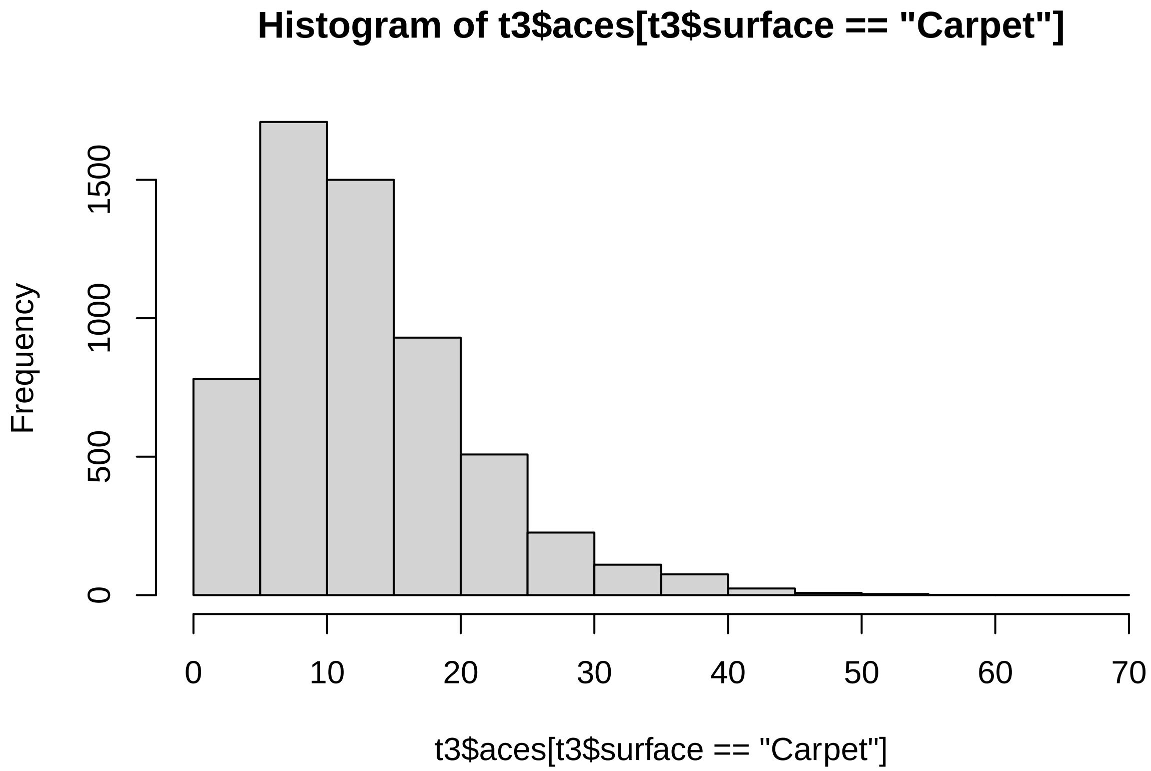
Zadatak 3. Ima li razlike u broju serviranih asova na različitim podlogama?

```
# Provjera homogenosti i normalnosti (Bartletov test)
# Vizualizacija po grupama Lili
# Kruskal Wallis

t3 <- all_matches %>%
  filter(!is.na(w_ace) & !is.na(l_ace) & !is.na(surface) & w_ace != "" & l_ace != "" & surface != "")
t3 <- select(t3, surface, w_ace, l_ace)
```

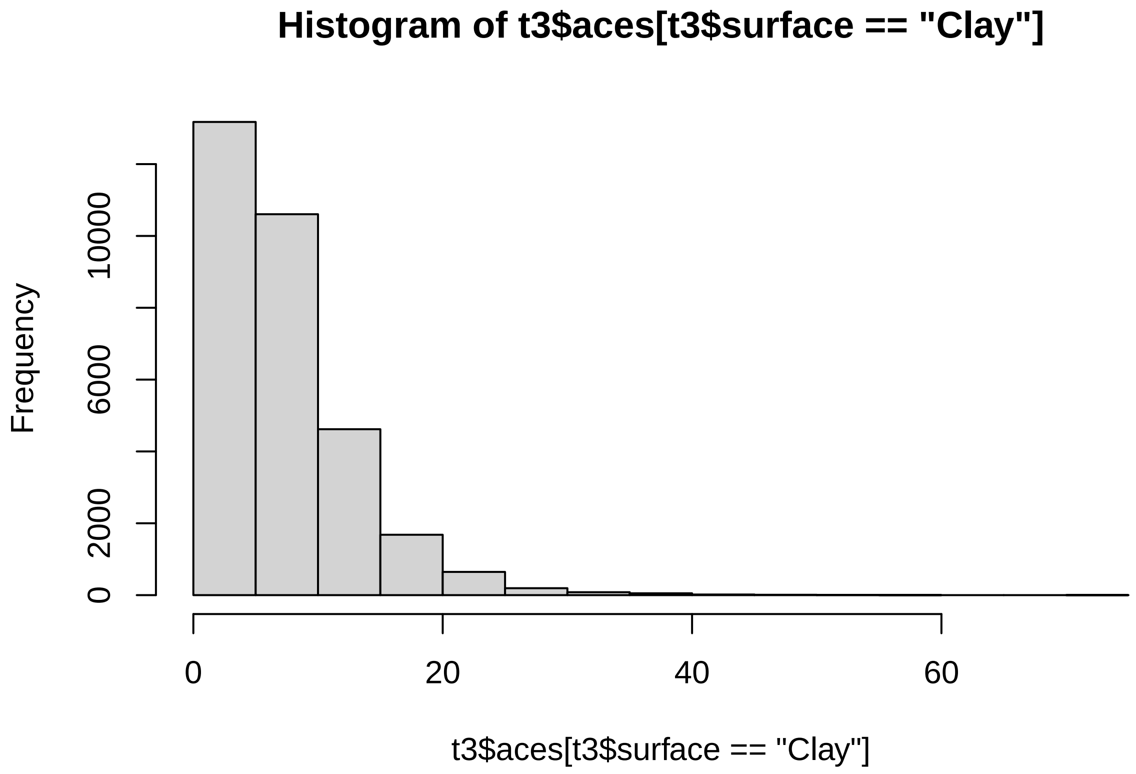
```r
t3 <- t3 %>%
  mutate(aces = w_ace + l_ace)

hist(t3$aces[t3$surface=='Hard'])
```



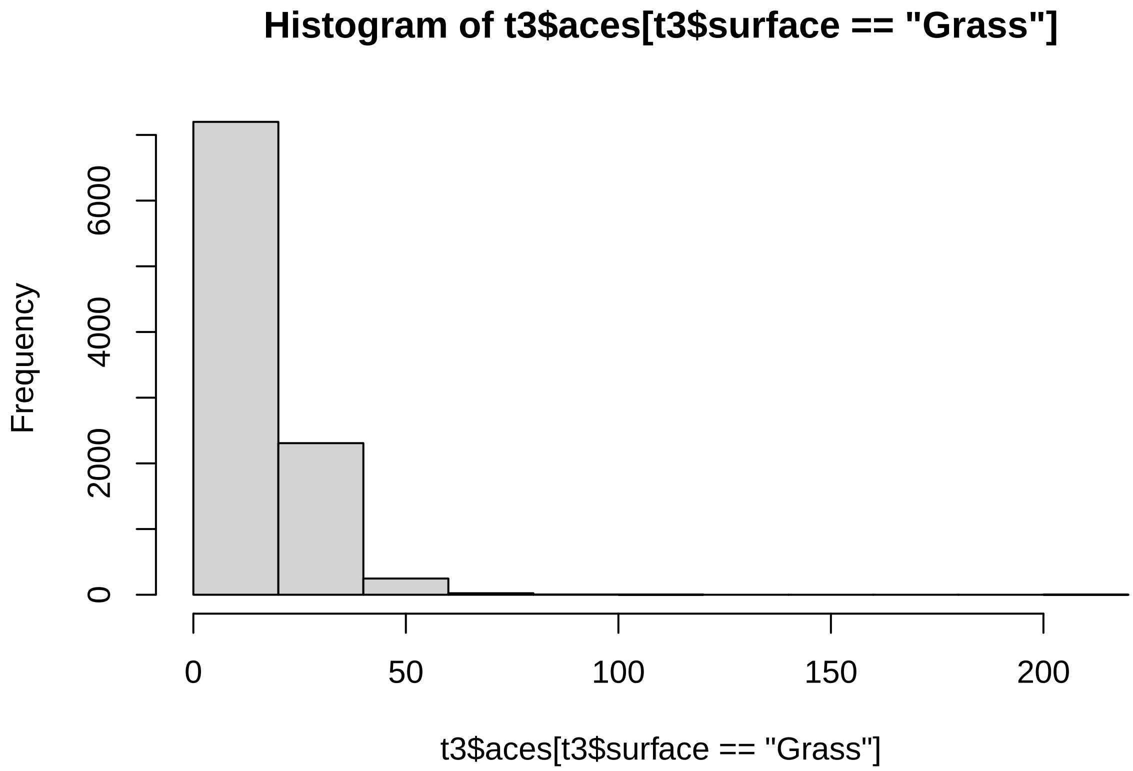
```r
hist(t3$aces[t3$surface=='Carpet'])
```



```r
hist(t3$aces[t3$surface=='Clay'])
```



```r
hist(t3$aces[t3$surface=='Grass'])
```



```r
require(nortest)
print(lillie.test(t3$aces[t3$surface=='Hard']))
```

```
##
##  Lilliefors (Kolmogorov-Smirnov) normality test
##
## data:  t3$aces[t3$surface == "Hard"]
## D = 0.11436, p-value < 2.2e-16
```

```r
print(lillie.test(t3$aces[t3$surface=='Carpet']))
```

```
##
##  Lilliefors (Kolmogorov-Smirnov) normality test
##
## data:  t3$aces[t3$surface == "Carpet"]
## D = 0.10864, p-value < 2.2e-16
```

```r
print(lillie.test(t3$aces[t3$surface=='Clay']))
```

```
##
##  Lilliefors (Kolmogorov-Smirnov) normality test
##
## data:  t3$aces[t3$surface == "Clay"]
## D = 0.13505, p-value < 2.2e-16
```

```r
print(lillie.test(t3$aces[t3$surface=='Grass']))
```

```
##
##  Lilliefors (Kolmogorov-Smirnov) normality test
##
## data:  t3$aces[t3$surface == "Grass"]
## D = 0.10802, p-value < 2.2e-16
```

```r
bartlett.test(t3$aces ~ t3$surface)
```

```
##
##  Bartlett test of homogeneity of variances
##
## data:  t3$aces by t3$surface
## Bartlett's K-squared = 7049.2, df = 3, p-value < 2.2e-16
```

```r
var((t3$aces[t3$surface=='Hard']))
```

```
## [1] 65.28138
```

```r
var((t3$aces[t3$surface=='Carpet']))
```

```
## [1] 63.26659
```

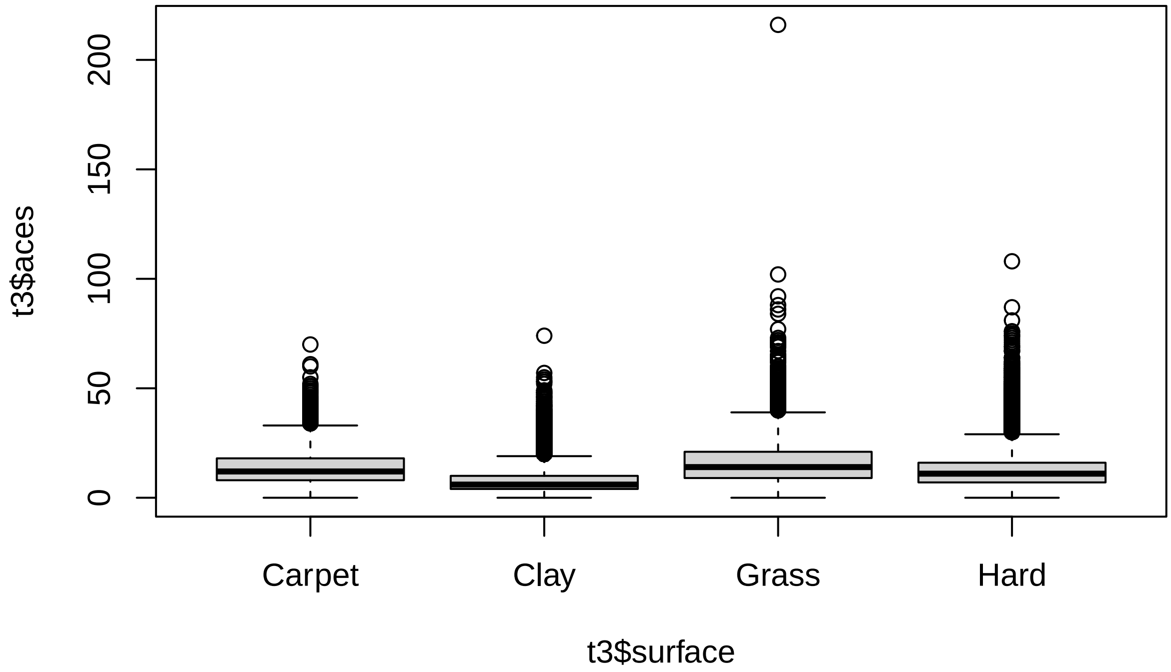
```r
var((t3$aces[t3$surface=='Clay']))
```

```
## [1] 31.9019
```

```r
var((t3$aces[t3$surface=='Grass']))
```

```
## [1] 104.5289
```

```r
boxplot(t3$aces ~ t3$surface)
```



```r
aov_res <- aov(aces~surface, data=t3)
print(summary(aov_res))
```

```
##                Df  Sum Sq Mean Sq F value Pr(>F)    
## surface         3  754563  251521    4319 <2e-16 ***
## Residuals   94471 5501707      58                   
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
kruskal.test(aces~surface, data=t3)
```

```
## 
##  Kruskal-Wallis rank sum test
## 
## data:  aces by surface
## Kruskal-Wallis chi-squared = 13657, df = 3, p-value < 2.2e-16
```

TODO Opis ispisa

Zadatak 4. Kakva je veza između vrste terena i vjerojatnosti da će mečevi otići u peti set?

```
##
```

```
##          FALSE TRUE
##   Carpet   700  179
##   Clay    5550 1240
##   Grass   3471  819
##   Hard    9090 2054
```

TODO Opis ispisa

Kontingencijskoj tablici dodajemo sume redaka i stupaca:

```
##
##          FALSE  TRUE   Sum
##   Carpet   700   179   879
##   Clay    5550  1240  6790
##   Grass   3471   819  4290
##   Hard    9090  2054 11144
##   Sum    18811  4292 23103
```

TODO Opis ispisa

Pretpostavka testa je da očekivana frekvencija pojedinog razreda mora biti veća ili jednaka 5 (`chisq.test()` pretpostavlja da je ovaj uvjet zadovoljen stoga je prije provođenja testa potrebno to provjeriti):

```
## Očekivane frekvencije za razred  FALSE - Carpet :  715.7022
## Očekivane frekvencije za razred  FALSE - Clay :  5528.576
## Očekivane frekvencije za razred  FALSE - Grass :  3493.018
## Očekivane frekvencije za razred  FALSE - Hard :  9073.704
## Očekivane frekvencije za razred  TRUE - Carpet :  163.2978
## Očekivane frekvencije za razred  TRUE - Clay :  1261.424
## Očekivane frekvencije za razred  TRUE - Grass :  796.9822
## Očekivane frekvencije za razred  TRUE - Hard :  2070.296
```

Sve očekivane frekvencije su veće od 5, nastavljamo sa χ^2 testom.

```
##
##  Pearson's Chi-squared test
##
## data:  contingency_table
## X-squared = 3.2059, df = 3, p-value = 0.361
```

TODO Opis ispisa

Zadatak 5. Možemo li procijeniti broj asova koje će igrač odservirati u tekućoj godini (zadnjoj dostupnoj sezoni) na temelju njegovih rezultata iz prethodnih sezona?

```
## Warning: Using an external vector in selections was deprecated in tidyselect 1.1.0.
## i Please use `all_of()` or `any_of()` instead.
##   # Was:
##   data %>% select(features)
##
##   # Now:
```

```
##   data %>% select(all_of(features))
##
## See <https://tidyselect.r-lib.org/reference/faq-external-vector.html>.
## This warning is displayed once every 8 hours.
## Call ‘lifecycle::last_lifecycle_warnings()‘ to see where this warning was
## generated.
```

```
## ‘summarise()‘ has grouped output by ’player_id’, ’year’, ’winner_ht’. You can
## override using the ‘.groups‘ argument.
## ‘summarise()‘ has grouped output by ’player_id’, ’year’, ’loser_ht’. You can
## override using the ‘.groups‘ argument.
```

```
## # A tibble: 7,417 x 9
## # Groups:   player_id, year, height [7,417]
##    player_id  year height hand  total_aces avg_1stIn avg_1stWon  svpt    df
##        <int> <dbl>  <int> <fct>      <int>     <dbl>      <dbl> <dbl> <int>
##  1    100284  1991    178 L             45      60.3       40.5  90.4    38
##  2    100284  1992    178 L             37      53.6       36.1  80.3    31
##  3    100284  1993    178 L              4      57         40    92.3    11
##  4    100284  1994    178 L              2      61         36    89       5
##  5    100284  1995    178 L              7      43         31.5  78.5    10
##  6    100529  1991    185 R            168      45.3       36.2  81.2    43
##  7    100529  1992    185 R             87      38.3       30.5  78.3    47
##  8    100532  1991    175 R             17      33         26.3  66       8
##  9    100581  1991    180 L            205      39.0       30.8  69.9   123
## 10    100581  1992    180 L            175      50.6       40.3  86.3   126
## # i 7,407 more rows
```

```
## # A tibble: 10,396 x 9
## # Groups:   player_id, year, height [10,396]
##    player_id  year height hand  total_aces avg_1stIn avg_1stWon  svpt    df
##        <int> <dbl>  <int> <fct>      <int>     <dbl>      <dbl> <dbl> <int>
##  1    100282  1992    180 L              0      67.5       40.5  96       5
##  2    100284  1991    178 L              9      49.2       27.1  75.6    34
##  3    100284  1992    178 L             25      57.9       33.4  90.6    46
##  4    100284  1993    178 L              4      37.4       22.2  60.4    14
##  5    100284  1994    178 L              1      56         34    87.3     3
##  6    100284  1995    178 L              3      48         29    67       2
##  7    100284  1996    178 L              3      55         30    93       2
##  8    100286  1991    168 R              0      32         18    60       2
##  9    100321  1993    193 R              0      34         14    48       0
## 10    100431  1992    178 R              8      46.5       30.5  76       4
## # i 10,386 more rows
```

```
## # A tibble: 40 x 9
## # Groups:   player_id, year, height [20]
##    player_id  year height hand  total_aces avg_1stIn avg_1stWon  svpt    df
##        <int> <dbl>  <int> <fct>      <int>     <dbl>      <dbl> <dbl> <int>
##  1    104925  2004    188 R              4      60         39    91       2
##  2    104925  2005    188 R             43      62.1       45.4  96.4    26
##  3    104925  2006    188 R            216      49.3       37    79.3    92
##  4    104925  2007    188 R            420      54.2       40.0  83.5   147
##  5    104925  2008    188 R            413      47.3       35.6  72.3   113
##  6    104925  2009    188 R            420      46.2       34.3  73.0   212
##  7    104925  2010    188 R            232      49.2       35.9  77.5   198
##  8    104925  2011    188 R            320      47.0       35.2  71.9   131
##  9    104925  2012    188 R            456      47.4       36.0  73.6   117
## 10    104925  2013    188 R            424      47.5       36.6  72.4    94
## 11    104925  2014    188 R            371      50.8       38.5  75.9    91
## 12    104925  2015    188 R            441      48.5       36.4  72.9   124
## 13    104925  2016    188 R            263      48.6       36.2  74.5   168
## 14    104925  2017    188 R            138      51.0       37.8  76.6    56
## 15    104925  2018    188 R            286      50.2       38.2  75.7   117
## 16    104925  2019    188 R            332      46.2       36.4  70.4   136
## 17    104925  2020    188 R            257      50.5       38.5  78.4   125
## 18    104925  2021    188 R            416      55.7       43.1  85.4   130
## 19    104925  2022    188 R            244      46.0       36.7  70.1    66
## 20    104925  2023    188 R            295      53.8       42.2  84.9   128
## 21    104925  2004    188 R             22      57.3       34    93.7    19
## 22    104925  2005    188 R             45      57         37.6  91.3    32
## 23    104925  2006    188 R             63      52.3       34.2  82.2    59
## 24    104925  2007    188 R             98      49         32.2  79.9    48
## 25    104925  2008    188 R             73      53.8       36.6  84.6    40
## 26    104925  2009    188 R             82      53.9       35.9  86.8    51
## 27    104925  2010    188 R             72      61.1       39.9  93.1    84
## 28    104925  2011    188 R             23      57.2       36.6  88.4    12
## 29    104925  2012    188 R             46      54         37.2  87.4    30
## 30    104925  2013    188 R             52      73.1       47.2 110.     24
## 31    104925  2014    188 R             57      60         41.5  91.4    14
## 32    104925  2015    188 R             30      60.2       39.8  91.8    11
## 33    104925  2016    188 R             38      51.8       35    82.1    20
## 34    104925  2017    188 R             31      57.8       38.6  90.1    23
## 35    104925  2018    188 R             56      57.4       38.8  87.1    35
## 36    104925  2019    188 R             60      61.4       40.3  91.3    32
## 37    104925  2020    188 R             21      45.6       31.2  72        12
## 38    104925  2021    188 R             31      56.4       39.6  92        18
## 39    104925  2022    188 R             38      69         45.2 106      22
## 40    104925  2023    188 R             15      66         41   100.     15
```

```
## ‘summarise()‘ has grouped output by ’player_id’, ’year’, ’height’. You can
## override using the ‘.groups‘ argument.
```

```
## # A tibble: 20 x 9
## # Groups:   player_id, year, height [20]
##    player_id  year height hand  total_aces avg_1stIn avg_1stWon  svpt    df
##        <int> <dbl>  <int> <fct>      <int>     <dbl>      <dbl> <dbl> <int>
##  1    104925  2004    188 R             26      58.7       36.5  92.3    21
##  2    104925  2005    188 R             88      59.6       41.5  93.9    58
##  3    104925  2006    188 R            279      50.8       35.6  80.8   151
##  4    104925  2007    188 R            518      51.6       36.1  81.7   195
##  5    104925  2008    188 R            486      50.5       36.1  78.4   153
##  6    104925  2009    188 R            502      50.0       35.1  79.9   263
##  7    104925  2010    188 R            304      55.1       37.9  85.3   282
##  8    104925  2011    188 R            343      52.1       35.9  80.2   143
##  9    104925  2012    188 R            502      50.7       36.6  80.5   147
## 10    104925  2013    188 R            476      60.3       41.9  91.0   118
## 11    104925  2014    188 R            428      55.4       40.0  83.6   105
## 12    104925  2015    188 R            471      54.3       38.1  82.4   135
## 13    104925  2016    188 R            301      50.2       35.6  78.3   188
## 14    104925  2017    188 R            169      54.4       38.2  83.4    79
## 15    104925  2018    188 R            342      53.8       38.5  81.4   152
## 16    104925  2019    188 R            392      53.8       38.3  80.8   168
## 17    104925  2020    188 R            278      48.1       34.8  75.2   137
## 18    104925  2021    188 R            447      56.0       41.4  88.7   148
## 19    104925  2022    188 R            282      57.5       40.9  88.1    88
## 20    104925  2023    188 R            310      59.9       41.6  92.6   143
```

```
## # A tibble: 20 x 10
## # Groups:   player_id, year, height [20]
##    player_id  year height hand  total_aces avg_1stIn avg_1stWon  svpt    df
##        <int> <dbl>  <int> <fct>      <int>     <dbl>      <dbl> <dbl> <int>
##  1    104925  2004    188 R             26      58.7       36.5  92.3    21
##  2    104925  2005    188 R             88      59.6       41.5  93.9    58
##  3    104925  2006    188 R            279      50.8       35.6  80.8   151
##  4    104925  2007    188 R            518      51.6       36.1  81.7   195
##  5    104925  2008    188 R            486      50.5       36.1  78.4   153
##  6    104925  2009    188 R            502      50.0       35.1  79.9   263
##  7    104925  2010    188 R            304      55.1       37.9  85.3   282
##  8    104925  2011    188 R            343      52.1       35.9  80.2   143
##  9    104925  2012    188 R            502      50.7       36.6  80.5   147
## 10    104925  2013    188 R            476      60.3       41.9  91.0   118
## 11    104925  2014    188 R            428      55.4       40.0  83.6   105
## 12    104925  2015    188 R            471      54.3       38.1  82.4   135
## 13    104925  2016    188 R            301      50.2       35.6  78.3   188
## 14    104925  2017    188 R            169      54.4       38.2  83.4    79
## 15    104925  2018    188 R            342      53.8       38.5  81.4   152
## 16    104925  2019    188 R            392      53.8       38.3  80.8   168
## 17    104925  2020    188 R            278      48.1       34.8  75.2   137
## 18    104925  2021    188 R            447      56.0       41.4  88.7   148
## 19    104925  2022    188 R            282      57.5       40.9  88.1    88
## 20    104925  2023    188 R            310      59.9       41.6  92.6   143
## # i 1 more variable: aces_in_following_year <int>
```

```
##        1        2        3        4
## 415.2551 508.1003 382.2384 331.1461
```