

statlearning-final

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R Markdown

FIFA 22 first we do libraries

```
library(knitr)
#library(kableExtra) #nice html tables
#library(magick)      #working with images
library(ggplot2)      #graphs
library(reshape2)     #dataframe reshaping
library(viridis)      #colors
```

```
## Loading required package: viridisLite
```

```
library(stringr)      #working with strings
library(FactoMineR)   #factor analysis (PCA)
library(factoextra)   #factor analysis (PCA)
```

```
## Welcome! Want to learn more? See two factoextra-related books at https://goo.gl/ve3WBa
```

```
#library(kohonen)      #self-organised maps/SOM
library("stringr")
```

```
# libraries
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(ggplot2)
library(MASS)
```

```
##
## Attaching package: 'MASS'

## The following object is masked from 'package:dplyr':
##
##      select

#library(randomForest)
library(class)
#library(caret)
library(gmodels)

## Warning: package 'gmodels' was built under R version 4.2.1

library(tidyverse)

## Warning: package 'tidyverse' was built under R version 4.2.1

## -- Attaching packages ----- tidyverse 1.3.1 --

## v tibble  3.1.7      v purrr   0.3.4
## v tidyr   1.2.0      v forcats 0.5.1
## v readr   2.1.2

## Warning: package 'readr' was built under R version 4.2.1

## Warning: package 'forcats' was built under R version 4.2.1

## -- Conflicts ----- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()     masks stats::lag()
## x MASS::select()  masks dplyr::select()

library(corrplot)

## Warning: package 'corrplot' was built under R version 4.2.1

## corrplot 0.92 loaded

library(gridExtra)

##
## Attaching package: 'gridExtra'

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

```
#library(mlbench)  
library(reshape)
```

```
## Warning: package 'reshape' was built under R version 4.2.1
```

```
##  
## Attaching package: 'reshape'
```

```
## The following objects are masked from 'package:tidyr':  
##  
##     expand, smiths
```

```
## The following object is masked from 'package:class':  
##  
##     condense
```

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

```
## The following objects are masked from 'package:reshape2':  
##  
##     colsplit, melt, recast
```

```
library(corrplot)  
library(caret)
```

```
## Warning: package 'caret' was built under R version 4.2.1
```

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

```
##  
## Attaching package: 'caret'
```

```
## The following object is masked from 'package:purrr':  
##  
##     lift
```

```
library(randomForest)
```

```
## Warning: package 'randomForest' was built under R version 4.2.1
```

```
## randomForest 4.7-1.1
```

```
## Type rfNews() to see new features/changes/bug fixes.
```

```
##  
## Attaching package: 'randomForest'
```

```
## The following object is masked from 'package:gridExtra':
##
##      combine

## The following object is masked from 'package:dplyr':
##
##      combine

## The following object is masked from 'package:ggplot2':
##
##      margin
```

```
library(cvms)
```

```
## Warning: package 'cvms' was built under R version 4.2.1
```

```
set.seed(123)
```

Data Cleaning

check dimensions, check columns

```
players_full <- read.csv("E:/horatiu/FIS/players_22.csv/players_22.csv") #full dataframe
dim(players_full) #full dataset
```

```
## [1] 19239    110
```

```
colnames(players_full)
```

```
##      [1] "sofifa_id"           "player_url"
##      [3] "short_name"         "long_name"
##      [5] "player_positions"   "overall"
##      [7] "potential"          "value_eur"
##      [9] "wage_eur"           "age"
##     [11] "dob"                "height_cm"
##     [13] "weight_kg"          "club_team_id"
##     [15] "club_name"          "league_name"
##     [17] "league_level"       "club_position"
##     [19] "club_jersey_number" "club_loaned_from"
##     [21] "club_joined"        "club_contract_valid_until"
##     [23] "nationality_id"     "nationality_name"
##     [25] "nation_team_id"     "nation_position"
##     [27] "nation_jersey_number" "preferred_foot"
##     [29] "weak_foot"          "skill_moves"
##     [31] "international_reputation" "work_rate"
##     [33] "body_type"          "real_face"
##     [35] "release_clause_eur" "player_tags"
##     [37] "player_traits"      "pace"
##     [39] "shooting"           "passing"
##     [41] "dribbling"          "defending"
```

```
## [43] "physic" "attacking_crossing"
## [45] "attacking_finishing" "attacking_heading_accuracy"
## [47] "attacking_short_passing" "attacking_volleys"
## [49] "skill_dribbling" "skill_curve"
## [51] "skill_fk_accuracy" "skill_long_passing"
## [53] "skill_ball_control" "movement_acceleration"
## [55] "movement_sprint_speed" "movement_agility"
## [57] "movement_reactions" "movement_balance"
## [59] "power_shot_power" "power_jumping"
## [61] "power_stamina" "power_strength"
## [63] "power_long_shots" "mentality_aggression"
## [65] "mentality_interceptions" "mentality_positioning"
## [67] "mentality_vision" "mentality_penalties"
## [69] "mentality_composure" "defending_marking_awareness"
## [71] "defending_standing_tackle" "defending_sliding_tackle"
## [73] "goalkeeping_diving" "goalkeeping_handling"
## [75] "goalkeeping_kicking" "goalkeeping_positioning"
## [77] "goalkeeping_reflexes" "goalkeeping_speed"
## [79] "ls" "st"
## [81] "rs" "lw"
## [83] "lf" "cf"
## [85] "rf" "rw"
## [87] "lam" "cam"
## [89] "ram" "lm"
## [91] "lcm" "cm"
## [93] "rcm" "rm"
## [95] "lwb" "ldm"
## [97] "cdm" "rdm"
## [99] "rwb" "lb"
## [101] "lcb" "cb"
## [103] "rcb" "rb"
## [105] "gk" "player_face_url"
## [107] "club_logo_url" "club_flag_url"
## [109] "nation_logo_url" "nation_flag_url"
```

```
head(players_full$preferred_foot, 20)
```

```
## [1] "Left" "Right" "Right" "Right" "Right" "Right" "Right" "Right" "Right"
## [10] "Right" "Right" "Right" "Left" "Right" "Right" "Right" "Right" "Left"
## [19] "Left" "Right"
```

###select relevant columns we also remove position stats because we want to predict positions

```
players_full <- players_full[players_full$league_level == 1,]
```

```
players_22 <- subset(players_full, select = c("short_name", "player_positions", "age", "height_cm", "weight",
dim(players_22)
```

```
## [1] 14918 42
```

```
head(players_22, n=5)
```

##	short_name	player_positions	age	height_cm	weight_kg	pace	shooting
## 1	L. Messi	RW, ST, CF	34	170	72	85	92
## 2	R. Lewandowski	ST	32	185	81	78	92
## 3	Cristiano Ronaldo	ST, LW	36	187	83	87	94
## 4	Neymar Jr	LW, CAM	29	175	68	91	83
## 5	K. De Bruyne	CM, CAM	30	181	70	76	86
##	passing	preferred_foot	weak_foot	dribbling	defending	physic	
## 1	91	Left	4	95	34	65	
## 2	79	Right	4	86	44	82	
## 3	80	Right	4	88	34	75	
## 4	86	Right	5	94	37	63	
## 5	93	Right	5	88	64	78	
##	attacking_crossing	attacking_finishing		attacking_heading_accuracy			
## 1	85	95		70			
## 2	71	95		90			
## 3	87	95		90			
## 4	85	83		63			
## 5	94	82		55			
##	attacking_short_passing	attacking_volleys		skill_dribbling	skill_curve		
## 1	91	88		96	93		
## 2	85	89		85	79		
## 3	80	86		88	81		
## 4	86	86		95	88		
## 5	94	82		88	85		
##	skill_fk_accuracy	skill_long_passing	skill_ball_control	movement_acceleration			
## 1	94	91	96	91			
## 2	85	70	88	77			
## 3	84	77	88	85			
## 4	87	81	95	93			
## 5	83	93	91	76			
##	movement_sprint_speed	movement_agility	movement_reactions	movement_balance			
## 1	80	91	94	95			
## 2	79	77	93	82			
## 3	88	86	94	74			
## 4	89	96	89	84			
## 5	76	79	91	78			
##	power_shot_power	power_jumping	power_stamina	power_strength	power_long_shots		
## 1	86	68	72	69	94		
## 2	90	85	76	86	87		
## 3	94	95	77	77	93		
## 4	80	64	81	53	81		
## 5	91	63	89	74	91		
##	mentality_aggression	mentality_interceptions	mentality_positioning				
## 1	44	40	93				
## 2	81	49	95				
## 3	63	29	95				
## 4	63	37	86				
## 5	76	66	88				
##	mentality_vision	mentality_penalties	mentality_composure				
## 1	95	75	96				
## 2	81	90	88				
## 3	76	88	95				
## 4	90	93	93				
## 5	94	83	89				

```
##    defending_marking_awareness defending_standing_tackle
## 1                                20                      35
## 2                                35                      42
## 3                                24                      32
## 4                                35                      32
## 5                                68                      65
##    defending_sliding_tackle
## 1                                24
## 2                                19
## 3                                24
## 4                                29
## 5                                53
```

```
summary(players_22)
```

```
##    short_name      player_positions      age      height_cm
## Length:14918      Length:14918      Min.   :16.00      Min.   :155
## Class :character   Class :character   1st Qu.:21.00      1st Qu.:176
## Mode  :character   Mode  :character   Median :25.00      Median :181
##                                     Mean   :25.34      Mean   :181
##                                     3rd Qu.:29.00      3rd Qu.:186
##                                     Max.   :54.00      Max.   :203
##                                     NA's   :61        NA's   :61
##    weight_kg      pace      shooting      passing
## Min.   : 49.00      Min.   :28.00      Min.   :18.0      Min.   :25.00
## 1st Qu.: 70.00      1st Qu.:62.00      1st Qu.:42.0      1st Qu.:51.00
## Median : 75.00      Median :69.00      Median :55.0      Median :58.00
## Mean   : 74.84      Mean   :68.33      Mean   :52.8      Mean   :57.88
## 3rd Qu.: 80.00      3rd Qu.:76.00      3rd Qu.:64.0      3rd Qu.:65.00
## Max.   :107.00      Max.   :97.00      Max.   :94.0      Max.   :93.00
## NA's   :61        NA's   :1725      NA's   :1725      NA's   :1725
##    preferred_foot      weak_foot      dribbling      defending
## Length:14918      Min.   :1.000      Min.   :27.00      Min.   :15.00
## Class :character   1st Qu.:3.000      1st Qu.:57.00      1st Qu.:38.00
## Mode  :character   Median :3.000      Median :64.00      Median :56.00
##                                     Mean   :2.948      Mean   :62.99      Mean   :52.03
##                                     3rd Qu.:3.000      3rd Qu.:70.00      3rd Qu.:65.00
##                                     Max.   :5.000      Max.   :95.00      Max.   :91.00
##                                     NA's   :61        NA's   :1725      NA's   :1725
##    physic      attacking_crossing      attacking_finishing
## Min.   :29.00      Min.   : 6      Min.   : 2.0
## 1st Qu.:59.00      1st Qu.:39      1st Qu.:31.0
## Median :66.00      Median :54      Median :50.0
## Mean   :64.89      Mean   :50      Mean   :46.2
## 3rd Qu.:72.00      3rd Qu.:64      3rd Qu.:62.0
## Max.   :90.00      Max.   :94      Max.   :95.0
## NA's   :1725      NA's   :61      NA's   :61
##    attacking_heading_accuracy      attacking_short_passing      attacking_volleys
## Min.   : 5.00      Min.   : 7.00      Min.   : 3.00
## 1st Qu.:44.00      1st Qu.:55.00      1st Qu.:30.00
## Median :55.00      Median :63.00      Median :44.00
## Mean   :51.95      Mean   :59.33      Mean   :42.89
## 3rd Qu.:64.00      3rd Qu.:69.00      3rd Qu.:57.00
## Max.   :93.00      Max.   :94.00      Max.   :90.00
```

```

## NA's :61          NA's :61          NA's :61
## skill_dribbling skill_curve skill_fk_accuracy skill_long_passing
## Min. : 4      Min. : 6.00 Min. : 4.00 Min. : 9.00
## 1st Qu.:50    1st Qu.:35.00 1st Qu.:31.00 1st Qu.:45.00
## Median :62    Median :49.00 Median :41.00 Median :57.00
## Mean :56     Mean :47.73 Mean :42.65 Mean :53.63
## 3rd Qu.:69    3rd Qu.:62.00 3rd Qu.:56.00 3rd Qu.:65.00
## Max. :96     Max. :94.00 Max. :94.00 Max. :93.00
## NA's :61     NA's :61 NA's :61 NA's :61
## skill_ball_control movement_acceleration movement_sprint_speed
## Min. : 8.00    Min. :14.0    Min. :15.00
## 1st Qu.:55.00 1st Qu.:58.0    1st Qu.:58.00
## Median :63.00  Median :68.0    Median :68.00
## Mean :58.88   Mean :64.7     Mean :64.77
## 3rd Qu.:70.00 3rd Qu.:75.0    3rd Qu.:75.00
## Max. :96.00   Max. :97.0     Max. :97.00
## NA's :61     NA's :61 NA's :61
## movement_agility movement_reactions movement_balance power_shot_power
## Min. :18.00    Min. :25.00    Min. :19.0    Min. :20.00
## 1st Qu.:55.00 1st Qu.:56.00    1st Qu.:56.0    1st Qu.:48.00
## Median :66.00  Median :62.00    Median :66.0    Median :59.00
## Mean :63.55   Mean :61.91     Mean :64.1     Mean :58.19
## 3rd Qu.:74.00 3rd Qu.:68.00    3rd Qu.:74.0    3rd Qu.:68.00
## Max. :96.00   Max. :94.00     Max. :96.0     Max. :95.00
## NA's :61     NA's :61 NA's :61 NA's :61
## power_jumping power_stamina power_strength power_long_shots
## Min. :24.00    Min. :12.00    Min. :19.00    Min. : 4.00
## 1st Qu.:57.00 1st Qu.:56.00    1st Qu.:57.00    1st Qu.:32.00
## Median :65.00  Median :67.00    Median :66.00    Median :51.00
## Mean :64.75   Mean :63.15     Mean :64.97     Mean :47.08
## 3rd Qu.:73.00 3rd Qu.:74.00    3rd Qu.:74.00    3rd Qu.:63.00
## Max. :95.00   Max. :97.00     Max. :96.00     Max. :94.00
## NA's :61     NA's :61 NA's :61 NA's :61
## mentality_aggression mentality_interceptions mentality_positioning
## Min. :10.00    Min. : 4.00    Min. : 2.00
## 1st Qu.:45.00 1st Qu.:26.00    1st Qu.:40.00
## Median :59.00  Median :53.00    Median :56.00
## Mean :55.85   Mean :46.95     Mean :50.76
## 3rd Qu.:69.00 3rd Qu.:64.00    3rd Qu.:65.00
## Max. :95.00   Max. :91.00     Max. :96.00
## NA's :61     NA's :61 NA's :61
## mentality_vision mentality_penalties mentality_composure
## Min. :10.00    Min. : 7.00    Min. :12.0
## 1st Qu.:45.00 1st Qu.:38.00    1st Qu.:50.0
## Median :56.00  Median :49.00    Median :59.0
## Mean :54.49   Mean :48.11     Mean :58.4
## 3rd Qu.:65.00 3rd Qu.:60.00    3rd Qu.:67.0
## Max. :95.00   Max. :93.00     Max. :96.0
## NA's :61     NA's :61 NA's :61
## defending_marking_awareness defending_standing_tackle defending_sliding_tackle
## Min. : 4.00    Min. : 5.00    Min. : 5.00
## 1st Qu.:29.00 1st Qu.:28.00    1st Qu.:26.00
## Median :52.00  Median :55.00    Median :53.00
## Mean :46.86   Mean :48.28     Mean :46.12

```



```
## 3rd Qu.:64.00          3rd Qu.:66.00          3rd Qu.:64.00
## Max.    :93.00          Max.    :93.00          Max.    :92.00
## NA's    :61            NA's    :61            NA's    :61
```

Check how many goalkeepers

```
#install.packages("stringr")      # Install & load stringr package
```

```
goalkeepers <- str_detect(players_22$player_positions, "GK")
sum(goalkeepers)
```

```
## [1] NA
```

```
#eliminate goalkeepers
```

```
players_22<-subset(players_22, player_positions!="GK")
which(apply(X = players_22, MARGIN = 2, FUN = anyNA) == TRUE) # check for NA
```

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

```
dim(players_22)
```

```
## [1] 13193    42
```

```
#head(players_22, n = 2)
```

```
players_22 <- na.omit(players_22) # delete NA
dim(players_22)
```

```
## [1] 13193    42
```

```
col<-colnames(players_22)
col
```

```
## [1] "short_name"          "player_positions"
## [3] "age"                 "height_cm"
## [5] "weight_kg"           "pace"
## [7] "shooting"            "passing"
## [9] "preferred_foot"      "weak_foot"
## [11] "dribbling"           "defending"
## [13] "physic"              "attacking_crossing"
## [15] "attacking_finishing" "attacking_heading_accuracy"
## [17] "attacking_short_passing" "attacking_volley"
## [19] "skill_dribbling"     "skill_curve"
## [21] "skill_fk_accuracy"   "skill_long_passing"
## [23] "skill_ball_control"  "movement_acceleration"
## [25] "movement_sprint_speed" "movement_agility"
## [27] "movement_reactions"  "movement_balance"
```

```
## [29] "power_shot_power"      "power_jumping"
## [31] "power_stamina"        "power_strength"
## [33] "power_long_shots"     "mentality_aggression"
## [35] "mentality_interceptions" "mentality_positioning"
## [37] "mentality_vision"     "mentality_penalties"
## [39] "mentality_composure"  "defending_marking_awareness"
## [41] "defending_standing_tackle" "defending_sliding_tackle"
```

Now we take only the main position of each player

```
players_22$player_positions<- word(players_22$player_positions, 1, sep = fixed(","))
unique(players_22$player_positions)
```

```
## [1] "RW" "ST" "LW" "CM" "CDM" "CF" "LM" "CB" "CAM" "LB" "RB" "RM"
## [13] "LWB" "RWB"
```

```
#insert picture of player positions
#modify left,right foot with -1,1
```

```
players_22$preferred_foot[players_22[, "preferred_foot"]== "Left"] <- as.numeric(-1)
players_22$preferred_foot[players_22[, "preferred_foot"]== "Right"] <- as.numeric(1)
players_22$preferred_foot <- as.numeric(players_22$preferred_foot)
# now we group them into the main 9 positions
```

```
#central back players
```

```
players_22$player_positions[players_22[, "player_positions"]== "LCB"|players_22[, "player_positions"]== "CB"]<- "CB"
```

```
#left back players
```

```
players_22$player_positions[players_22[, "player_positions"]== "LWB"|players_22[, "player_positions"]== "LB"]<- "LB"
```

```
#right back players
```

```
players_22$player_positions[players_22[, "player_positions"]== "RWB"|players_22[, "player_positions"]== "RB"]<- "RB"
```

```
#central defender midfielders
```

```
players_22$player_positions[players_22[, "player_positions"]== "LDM"|players_22[, "player_positions"]== "CDM"]<- "CDM"
```

```
#central midfielders
```

```
players_22$player_positions[players_22[, "player_positions"]== "LCM"|players_22[, "player_positions"]== "CM"]<- "CM"
```

```
#central attacking midfielder
```

```
players_22$player_positions[players_22[, "player_positions"]== "LAM"|players_22[, "player_positions"]== "CAM"]<- "CAM"
```

```
#left wingers
```

```
players_22$player_positions[players_22[, "player_positions"]== "LM"|players_22[, "player_positions"]== "LW"]<- "LW"
```

```
#right wingers
```

```
players_22$player_positions[players_22[, "player_positions"]== "RM"|players_22[, "player_positions"]== "RW"]<- "RW"
```

```
#strikers
```

```
players_22$player_positions[players_22[, "player_positions"]== "LS"|players_22[, "player_positions"]== "CF"]<- "CF"
```

```
#normalize numerical values
```

```

# normalization function
normalize <-function(x) { (x -min(x))/(max(x)-min(x))  }

# normalize
players_norm <- as.data.frame(lapply(players_22[, c(3:42)], normalize))
head(players_norm)

##      age height_cm weight_kg      pace  shooting  passing preferred_foot
## 1 0.4736842 0.3125000 0.4423077 0.8260870 0.9736842 0.9705882          0
## 2 0.4210526 0.6250000 0.6153846 0.7246377 0.9736842 0.7941176          1
## 3 0.5263158 0.6666667 0.6538462 0.8550725 1.0000000 0.8088235          1
## 4 0.3421053 0.4166667 0.3653846 0.9130435 0.8552632 0.8970588          1
## 5 0.3684211 0.5416667 0.4038462 0.6956522 0.8947368 1.0000000          1
## 6 0.1578947 0.5625000 0.4615385 1.0000000 0.9210526 0.8088235          1
##  weak_foot dribbling defending      physic attacking_crossing
## 1      0.75 1.0000000 0.2500000 0.5901639          0.8860759
## 2      0.75 0.8676471 0.3815789 0.8688525          0.7088608
## 3      0.75 0.8970588 0.2500000 0.7540984          0.9113924
## 4      1.00 0.9852941 0.2894737 0.5573770          0.8860759
## 5      1.00 0.8970588 0.6447368 0.8032787          1.0000000
## 6      0.75 0.9558824 0.2763158 0.7868852          0.7974684
##  attacking_finishing attacking_heading_accuracy attacking_short_passing
## 1      1.0000000          0.6973684          0.9577465
## 2      1.0000000          0.9605263          0.8732394
## 3      1.0000000          0.9605263          0.8028169
## 4      0.8588235          0.6052632          0.8873239
## 5      0.8470588          0.5000000          1.0000000
## 6      0.9764706          0.7236842          0.8732394
##  attacking_volleys skill_dribbling skill_curve skill_fk_accuracy
## 1      0.9750      1.0000000 0.9878049      1.0000000
## 2      0.9875      0.8589744 0.8170732      0.8928571
## 3      0.9500      0.8974359 0.8414634      0.8809524
## 4      0.9500      0.9871795 0.9268293      0.9166667
## 5      0.9000      0.8974359 0.8902439      0.8690476
## 6      0.9125      0.9615385 0.8292683      0.7023810
##  skill_long_passing skill_ball_control movement_acceleration
## 1      0.9726027      1.0000000      0.9142857
## 2      0.6849315      0.8888889      0.7142857
## 3      0.7808219      0.8888889      0.8285714
## 4      0.8356164      0.9861111      0.9428571
## 5      1.0000000      0.9305556      0.7000000
## 6      0.6986301      0.9305556      1.0000000
##  movement_sprint_speed movement_agility movement_reactions movement_balance
## 1      0.7571429      0.9275362      1.0000000      0.9857143
## 2      0.7428571      0.7246377      0.9846154      0.8000000
## 3      0.8714286      0.8550725      1.0000000      0.6857143
## 4      0.8857143      1.0000000      0.9230769      0.8285714
## 5      0.7000000      0.7536232      0.9538462      0.7428571
## 6      1.0000000      0.9420290      0.9846154      0.8142857
##  power_shot_power power_jumping power_stamina power_strength power_long_shots
## 1      0.8800000      0.5909091      0.6575342      0.6493506      1.0000000
## 2      0.9333333      0.8484848      0.7123288      0.8701299      0.9156627
## 3      0.9866667      1.0000000      0.7260274      0.7532468      0.9879518

```

```

## 4      0.8000000      0.5303030      0.7808219      0.4415584      0.8433735
## 5      0.9466667      0.5151515      0.8904110      0.7142857      0.9638554
## 6      0.8800000      0.7424242      0.8767123      0.7532468      0.8554217
##      mentality_aggression mentality_interceptions mentality_positioning
## 1      0.3200000      0.3703704      0.9642857
## 2      0.8133333      0.4814815      0.9880952
## 3      0.5733333      0.2345679      0.9880952
## 4      0.5733333      0.3333333      0.8809524
## 5      0.7466667      0.6913580      0.9047619
## 6      0.5600000      0.3456790      0.9523810
##      mentality_vision mentality_penalties mentality_composure
## 1      1.0000000      0.7750      1.0000000
## 2      0.8292683      0.9625      0.8787879
## 3      0.7682927      0.9375      0.9848485
## 4      0.9390244      1.0000      0.9545455
## 5      0.9878049      0.8750      0.8939394
## 6      0.8414634      0.8250      0.8787879
##      defending_marking_awareness defending_standing_tackle
## 1      0.1204819      0.3012048
## 2      0.3012048      0.3855422
## 3      0.1686747      0.2650602
## 4      0.3012048      0.2650602
## 5      0.6987952      0.6626506
## 6      0.1927711      0.2891566
##      defending_sliding_tackle
## 1      0.1707317
## 2      0.1097561
## 3      0.1707317
## 4      0.2317073
## 5      0.5243902
## 6      0.2682927

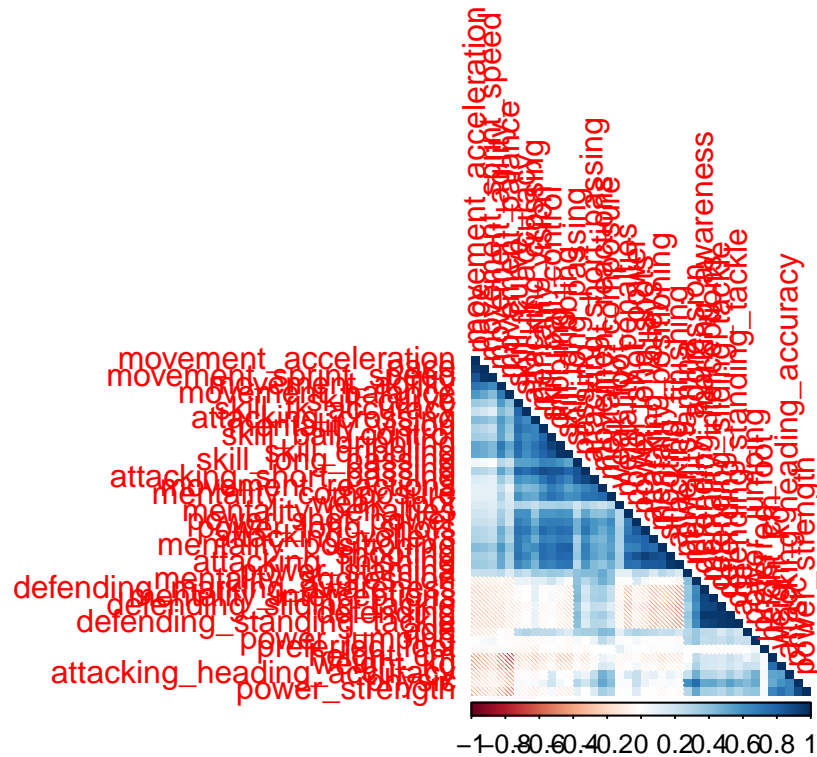
```

```
#check correlation matrix
```

```

#create numerical subset
cormatrix <- cor(players_norm)
corrplot(cor(players_norm), method = 'shade', type = 'lower', order = 'hclust' )

```



```
highcorr <- findCorrelation(cormatrix, cutoff=0.8)
highcorr
```

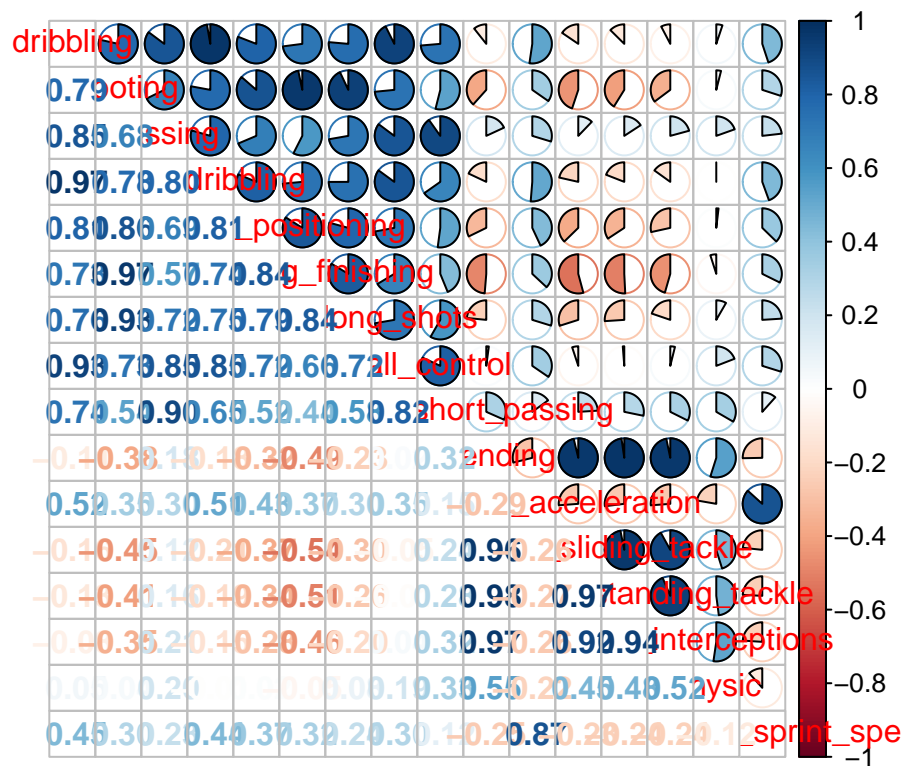
```
## [1] 9 5 6 17 34 13 31 21 15 10 22 40 39 33 11 23
```

```
col2<-colnames(players_norm)
col2
```

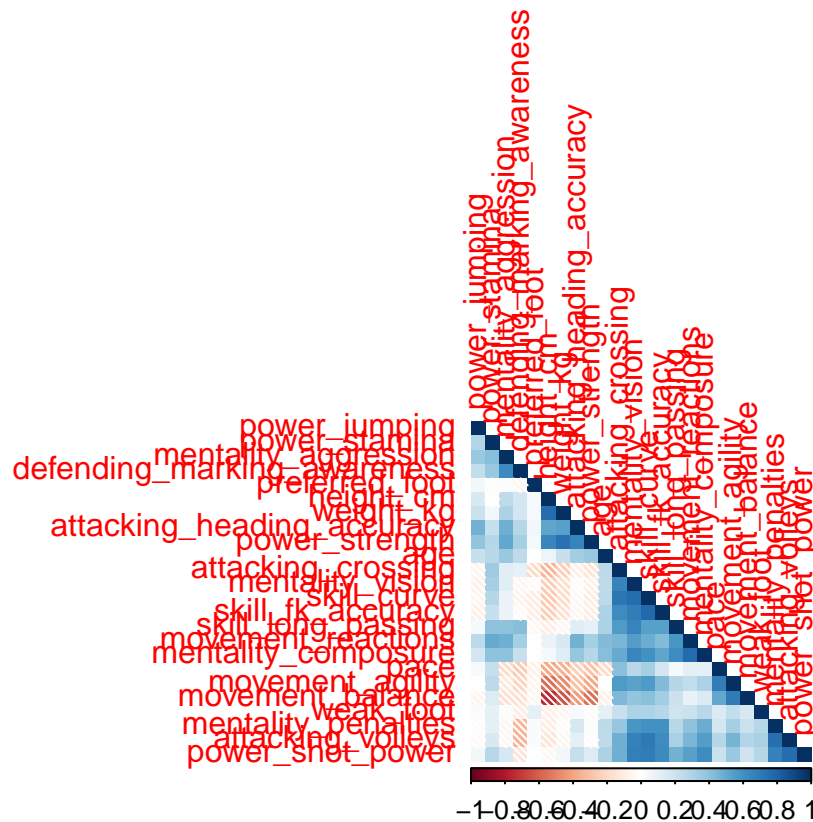
```
## [1] "age" "height_cm"
## [3] "weight_kg" "pace"
## [5] "shooting" "passing"
## [7] "preferred_foot" "weak_foot"
## [9] "dribbling" "defending"
## [11] "physic" "attacking_crossing"
## [13] "attacking_finishing" "attacking_heading_accuracy"
## [15] "attacking_short_passing" "attacking_volleys"
## [17] "skill_dribbling" "skill_curve"
## [19] "skill_fk_accuracy" "skill_long_passing"
## [21] "skill_ball_control" "movement_acceleration"
## [23] "movement_sprint_speed" "movement_agility"
## [25] "movement_reactions" "movement_balance"
## [27] "power_shot_power" "power_jumping"
## [29] "power_stamina" "power_strength"
## [31] "power_long_shots" "mentality_aggression"
## [33] "mentality_interceptions" "mentality_positioning"
```

```
## [35] "mentality_vision"           "mentality_penalties"
## [37] "mentality_composure"       "defending_marking_awareness"
## [39] "defending_sliding_tackle"   "defending_sliding_tackle"
```

```
col2<-col2[~highcorr]
corrplot.mixed(cor(players_norm[highcorr]), lower = "number", upper="pie") # it looks much better so we
```



```
corrplot(cor(players_norm[col2]), type = 'lower', method = 'shade', order = 'hclust')
```



```
players_model <- subset(players_norm)
players_model$player_positions <- c(players_22$player_positions)
head(players_model)
```

##	age	height_cm	weight_kg	pace	shooting	passing	preferred_foot
## 1	0.4736842	0.3125000	0.4423077	0.8260870	0.9736842	0.9705882	0
## 2	0.4210526	0.6250000	0.6153846	0.7246377	0.9736842	0.7941176	1
## 3	0.5263158	0.6666667	0.6538462	0.8550725	1.0000000	0.8088235	1
## 4	0.3421053	0.4166667	0.3653846	0.9130435	0.8552632	0.8970588	1
## 5	0.3684211	0.5416667	0.4038462	0.6956522	0.8947368	1.0000000	1
## 6	0.1578947	0.5625000	0.4615385	1.0000000	0.9210526	0.8088235	1
##	weak_foot	dribbling	defending	physic	attacking_crossing		
## 1	0.75	1.0000000	0.2500000	0.5901639		0.8860759	
## 2	0.75	0.8676471	0.3815789	0.8688525		0.7088608	
## 3	0.75	0.8970588	0.2500000	0.7540984		0.9113924	
## 4	1.00	0.9852941	0.2894737	0.5573770		0.8860759	
## 5	1.00	0.8970588	0.6447368	0.8032787		1.0000000	
## 6	0.75	0.9558824	0.2763158	0.7868852		0.7974684	
##	attacking_finishing	attacking_heading_accuracy	attacking_short_passing				
## 1	1.0000000		0.6973684			0.9577465	
## 2	1.0000000		0.9605263			0.8732394	
## 3	1.0000000		0.9605263			0.8028169	
## 4	0.8588235		0.6052632			0.8873239	
## 5	0.8470588		0.5000000			1.0000000	
## 6	0.9764706		0.7236842			0.8732394	

##	attacking_volleys	skill_dribbling	skill_curve	skill_fk_accuracy	
## 1	0.9750	1.0000000	0.9878049	1.0000000	
## 2	0.9875	0.8589744	0.8170732	0.8928571	
## 3	0.9500	0.8974359	0.8414634	0.8809524	
## 4	0.9500	0.9871795	0.9268293	0.9166667	
## 5	0.9000	0.8974359	0.8902439	0.8690476	
## 6	0.9125	0.9615385	0.8292683	0.7023810	
##	skill_long_passing	skill_ball_control	movement_acceleration		
## 1	0.9726027	1.0000000	0.9142857		
## 2	0.6849315	0.8888889	0.7142857		
## 3	0.7808219	0.8888889	0.8285714		
## 4	0.8356164	0.9861111	0.9428571		
## 5	1.0000000	0.9305556	0.7000000		
## 6	0.6986301	0.9305556	1.0000000		
##	movement_sprint_speed	movement_agility	movement_reactions	movement_balance	
## 1	0.7571429	0.9275362	1.0000000	0.9857143	
## 2	0.7428571	0.7246377	0.9846154	0.8000000	
## 3	0.8714286	0.8550725	1.0000000	0.6857143	
## 4	0.8857143	1.0000000	0.9230769	0.8285714	
## 5	0.7000000	0.7536232	0.9538462	0.7428571	
## 6	1.0000000	0.9420290	0.9846154	0.8142857	
##	power_shot_power	power_jumping	power_stamina	power_strength	power_long_shots
## 1	0.8800000	0.5909091	0.6575342	0.6493506	1.0000000
## 2	0.9333333	0.8484848	0.7123288	0.8701299	0.9156627
## 3	0.9866667	1.0000000	0.7260274	0.7532468	0.9879518
## 4	0.8000000	0.5303030	0.7808219	0.4415584	0.8433735
## 5	0.9466667	0.5151515	0.8904110	0.7142857	0.9638554
## 6	0.8800000	0.7424242	0.8767123	0.7532468	0.8554217
##	mentality_aggression	mentality_interceptions	mentality_positioning		
## 1	0.3200000	0.3703704	0.9642857		
## 2	0.8133333	0.4814815	0.9880952		
## 3	0.5733333	0.2345679	0.9880952		
## 4	0.5733333	0.3333333	0.8809524		
## 5	0.7466667	0.6913580	0.9047619		
## 6	0.5600000	0.3456790	0.9523810		
##	mentality_vision	mentality_penalties	mentality_composure		
## 1	1.0000000	0.7750	1.0000000		
## 2	0.8292683	0.9625	0.8787879		
## 3	0.7682927	0.9375	0.9848485		
## 4	0.9390244	1.0000	0.9545455		
## 5	0.9878049	0.8750	0.8939394		
## 6	0.8414634	0.8250	0.8787879		
##	defending_marking_awareness	defending_standing_tackle			
## 1	0.1204819	0.3012048			
## 2	0.3012048	0.3855422			
## 3	0.1686747	0.2650602			
## 4	0.3012048	0.2650602			
## 5	0.6987952	0.6626506			
## 6	0.1927711	0.2891566			
##	defending_sliding_tackle	player_positions			
## 1	0.1707317	RW			
## 2	0.1097561	ST			
## 3	0.1707317	ST			
## 4	0.2317073	LW			

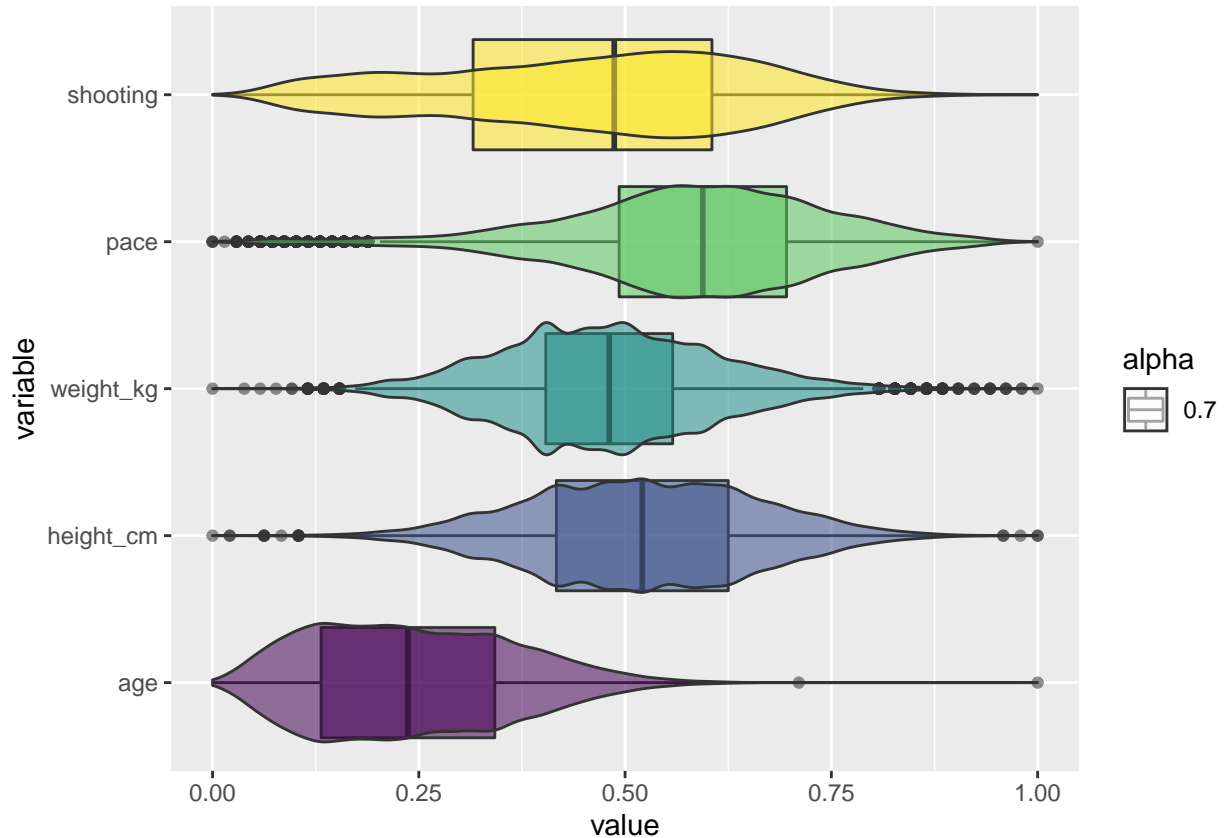

```
## 5          0.5243902      CM
## 6          0.2682927      ST
```

```
#here we do the cool violin plots to check distributions
```

```
par(mfrow=c(4,2))
```

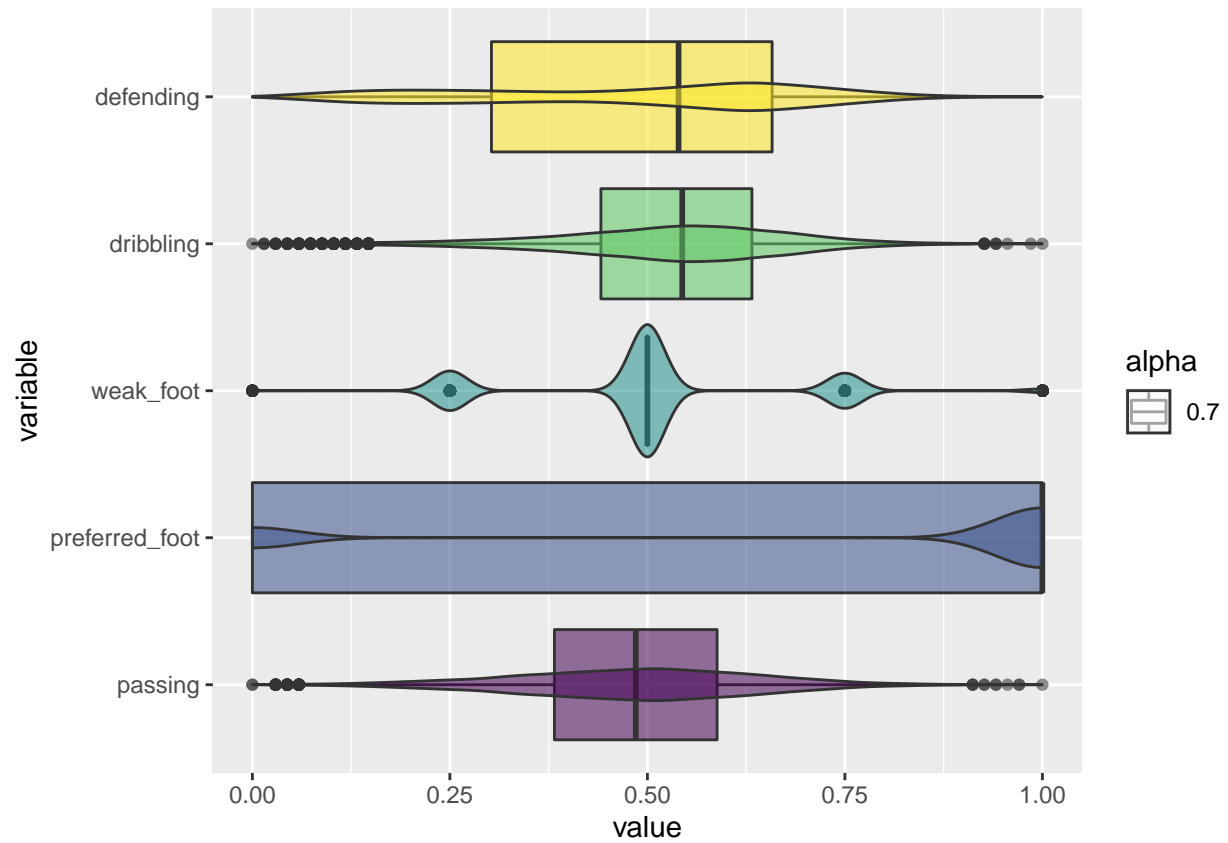
```
ggplot(data = melt(players_norm[,1:5]), aes(y = variable, x = value, fill = variable, alpha = 0.7)) + g
```

```
## Using as id variables
```



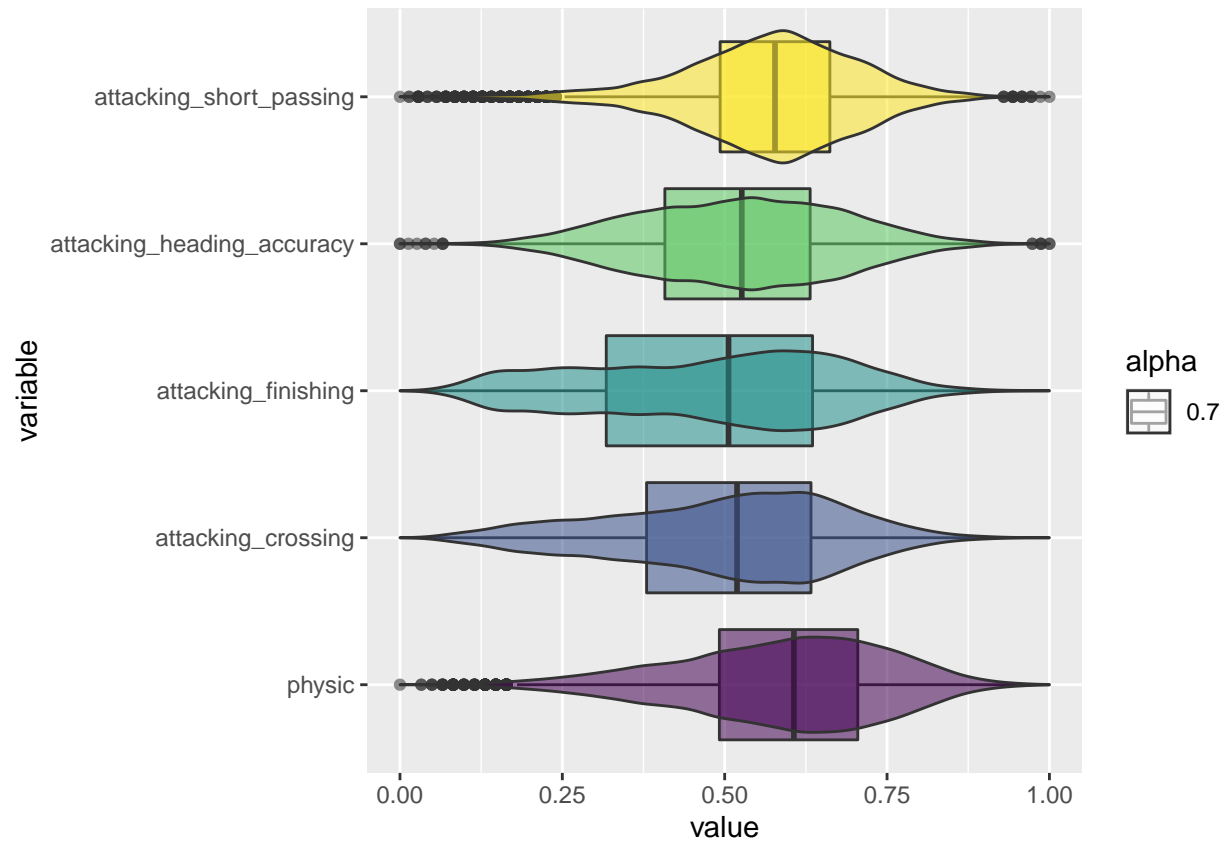
```
ggplot(data = melt(players_norm[,6:10]), aes(y = variable, x = value, fill = variable, alpha = 0.7)) + g
```

```
## Using as id variables
```



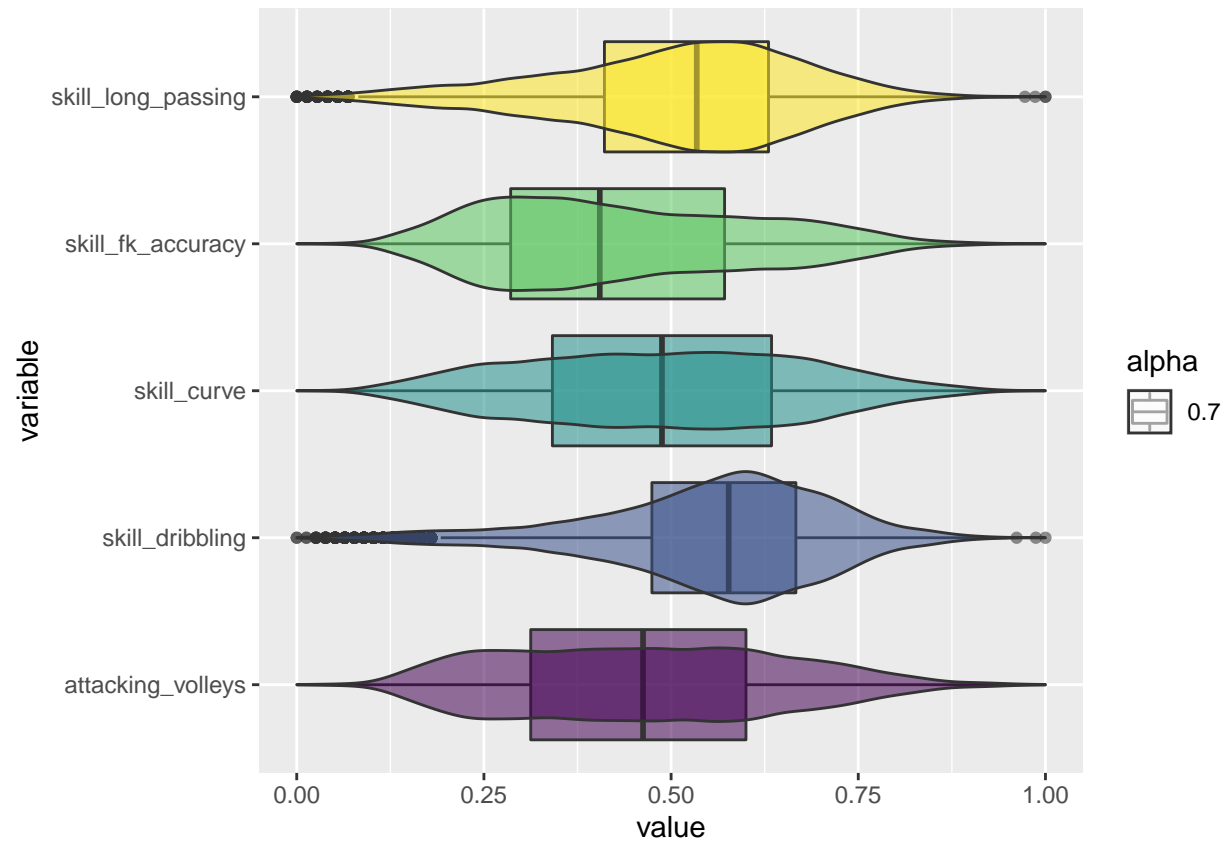
```
ggplot(data = melt(players_norm[,11:15]), aes(y = variable, x = value, fill = variable, alpha = 0.7)) +
```

```
## Using as id variables
```



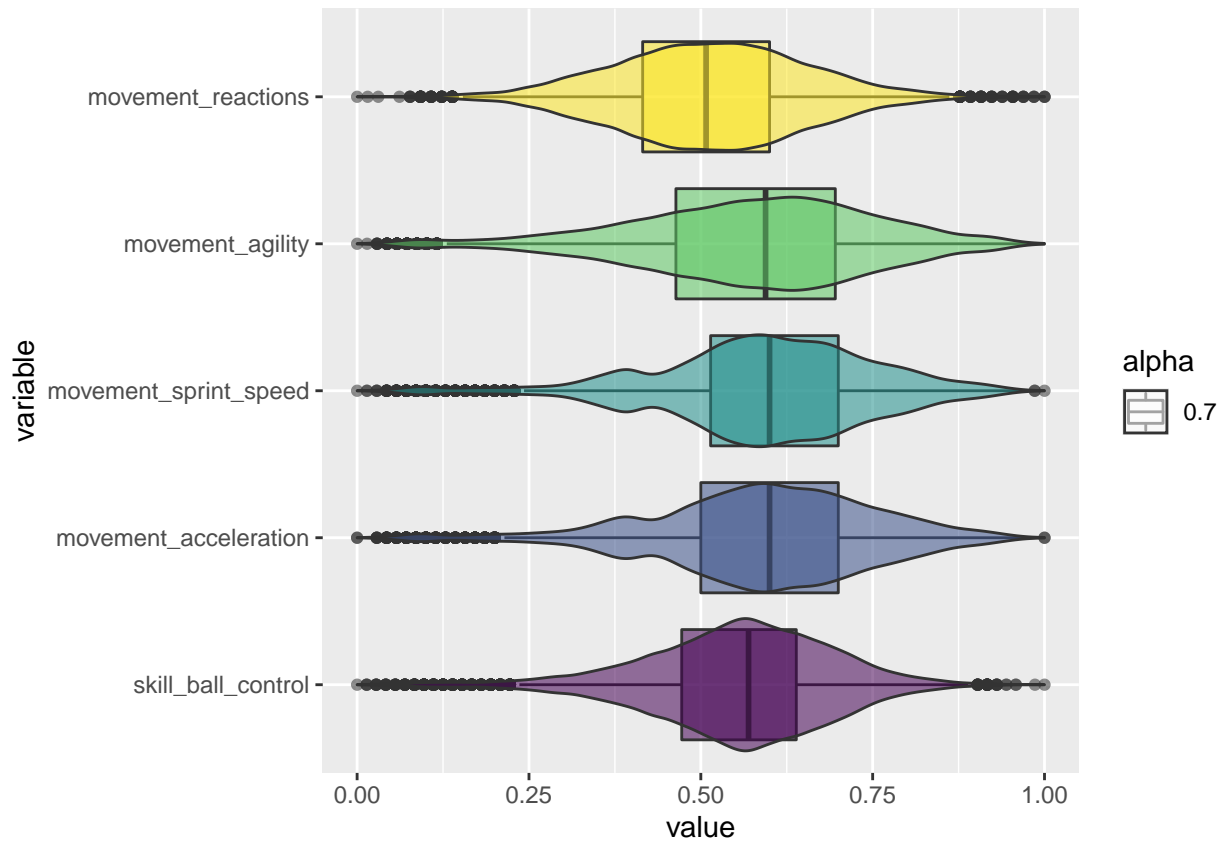
```
ggplot(data = melt(players_norm[,16:20]), aes(y = variable, x = value, fill = variable, alpha = 0.7)) +
```

```
## Using as id variables
```



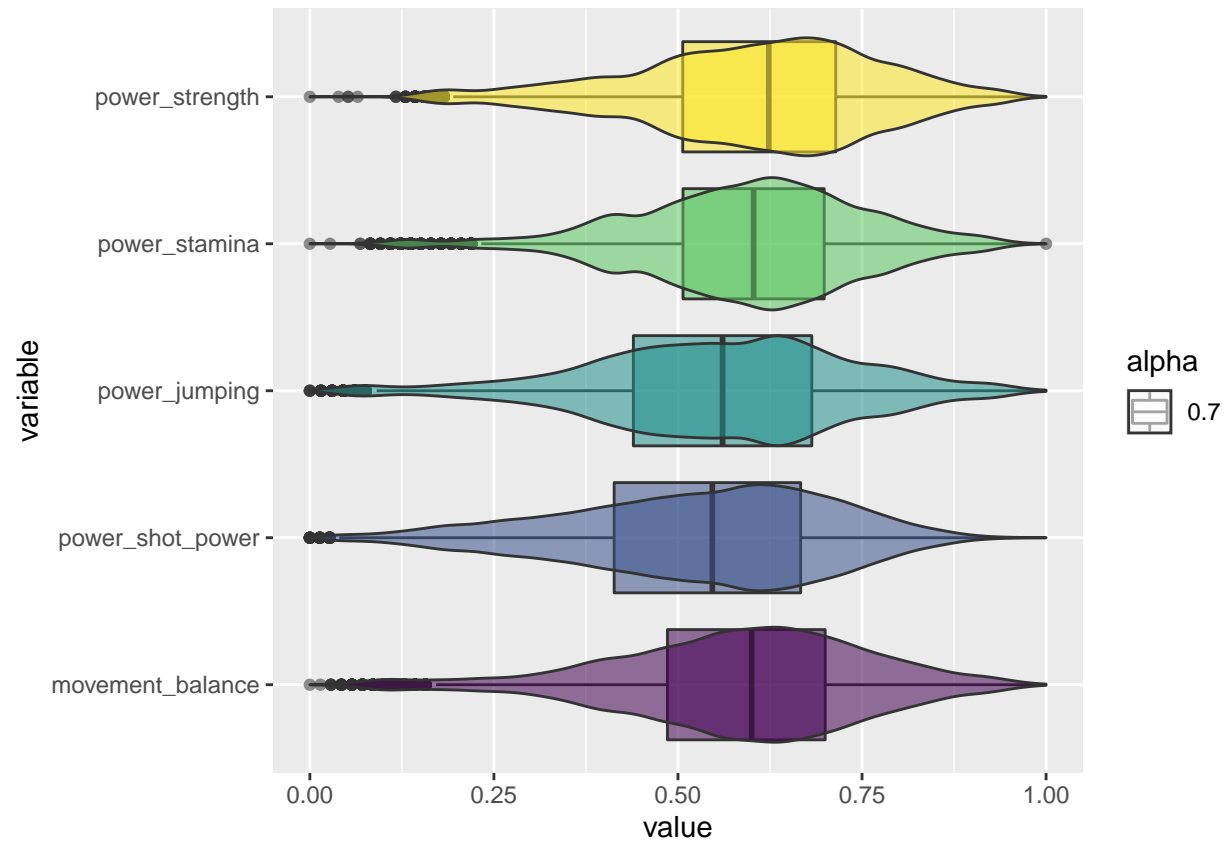
```
ggplot(data = melt(players_norm[,21:25]), aes(y = variable, x = value, fill = variable, alpha = 0.7)) +
```

```
## Using as id variables
```



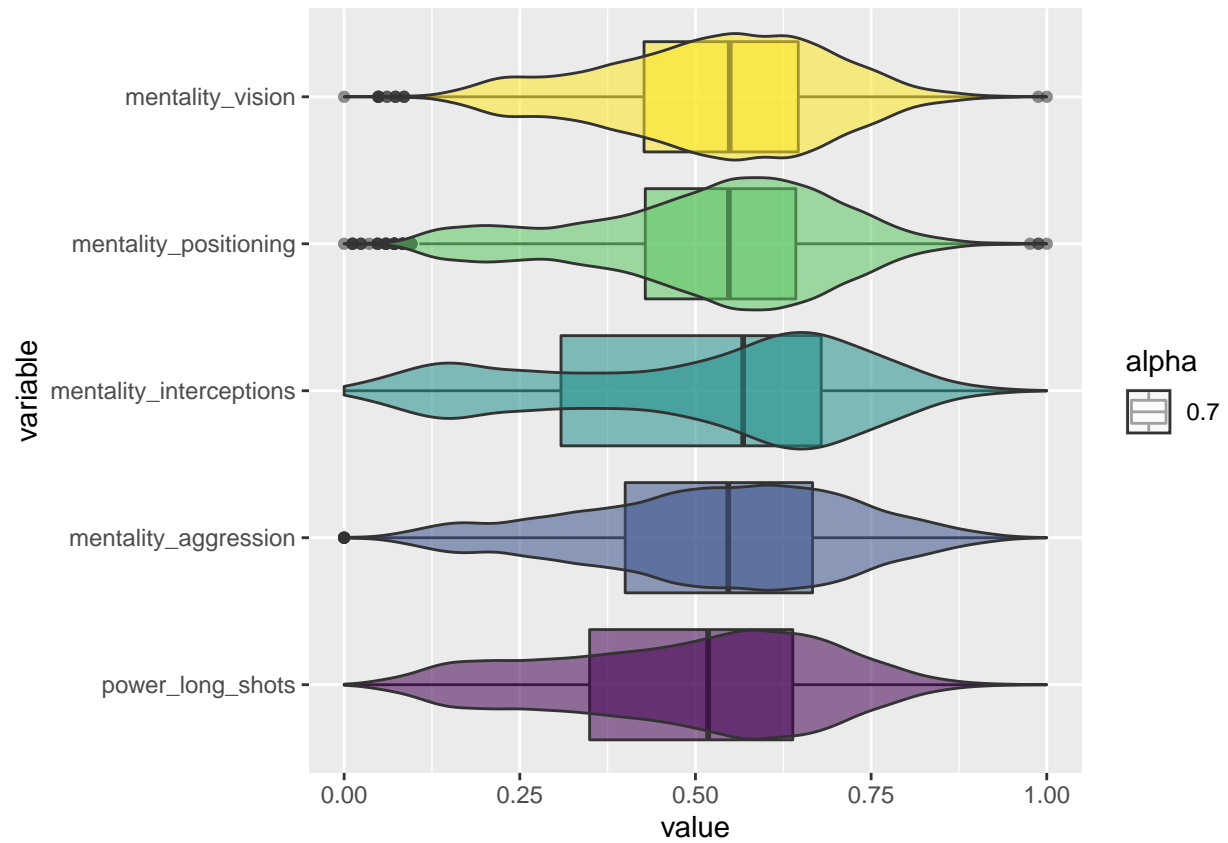
```
ggplot(data = melt(players_norm[,26:30]), aes(y = variable, x = value, fill = variable, alpha = 0.7)) +
```

```
## Using as id variables
```



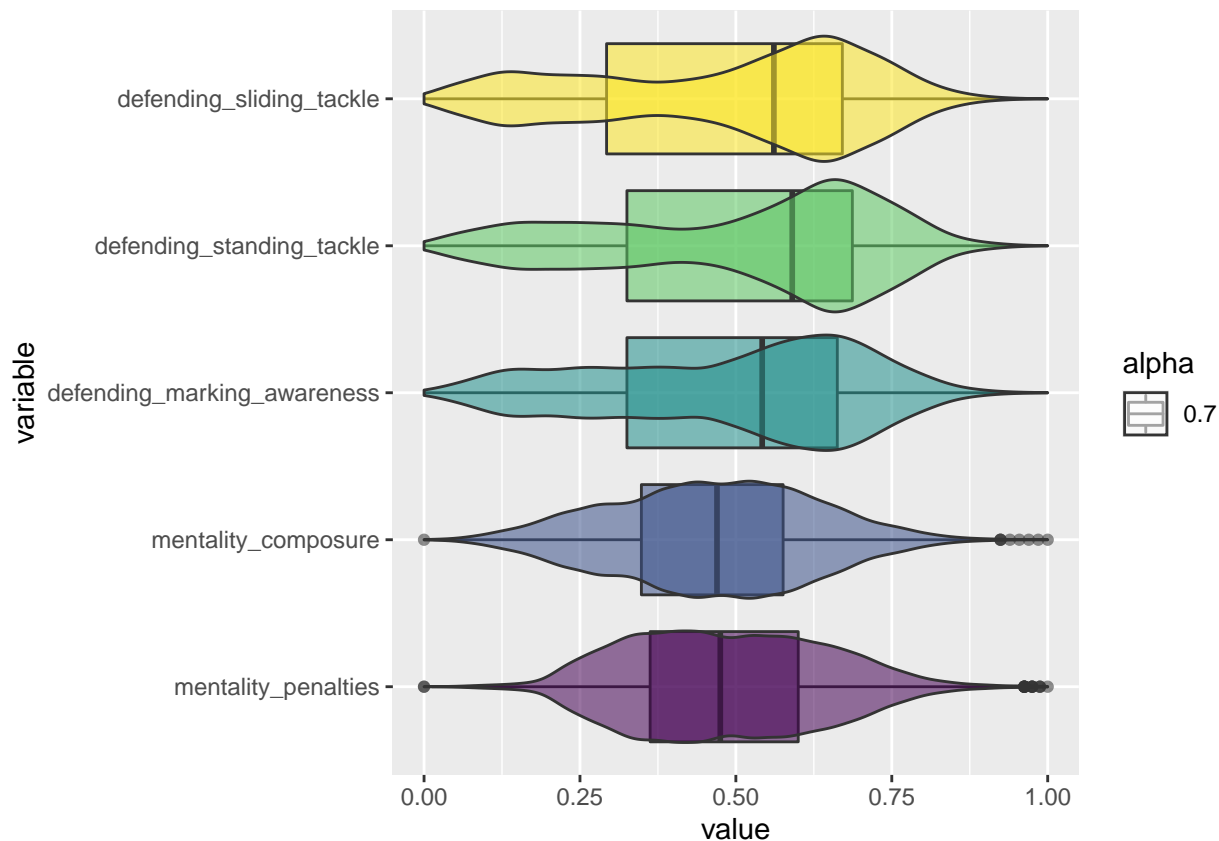
```
ggplot(data = melt(players_norm[,31:35]), aes(y = variable, x = value, fill = variable, alpha = 0.7)) +
```

```
## Using as id variables
```



```
ggplot(data = melt(players_norm[,36:40]), aes(y = variable, x = value, fill = variable, alpha = 0.7)) +
```

```
## Using as id variables
```



```
players.pca<-prcomp(players_norm,center=TRUE, scale.=TRUE)
summary(players.pca)
```

```
## Importance of components:
##              PC1    PC2    PC3    PC4    PC5    PC6    PC7
## Standard deviation  3.8338 2.9386 2.0527 1.53692 1.08836 1.00962 0.90009
## Proportion of Variance 0.3674 0.2159 0.1053 0.05905 0.02961 0.02548 0.02025
## Cumulative Proportion 0.3674 0.5833 0.6887 0.74772 0.77733 0.80281 0.82307
##              PC8    PC9    PC10   PC11   PC12   PC13   PC14
## Standard deviation  0.86204 0.78772 0.77920 0.70934 0.65328 0.6326 0.60847
## Proportion of Variance 0.01858 0.01551 0.01518 0.01258 0.01067 0.0100 0.00926
## Cumulative Proportion 0.84164 0.85716 0.87233 0.88491 0.89558 0.9056 0.91484
##              PC15   PC16   PC17   PC18   PC19   PC20   PC21
## Standard deviation  0.57770 0.54221 0.51429 0.49240 0.48928 0.4732 0.46759
## Proportion of Variance 0.00834 0.00735 0.00661 0.00606 0.00598 0.0056 0.00547
## Cumulative Proportion 0.92319 0.93054 0.93715 0.94321 0.94920 0.9548 0.96026
##              PC22   PC23   PC24   PC25   PC26   PC27   PC28
## Standard deviation  0.44503 0.43329 0.41573 0.39871 0.37169 0.35022 0.3462
## Proportion of Variance 0.00495 0.00469 0.00432 0.00397 0.00345 0.00307 0.0030
## Cumulative Proportion 0.96521 0.96990 0.97422 0.97820 0.98165 0.98472 0.9877
##              PC29   PC30   PC31   PC32   PC33   PC34   PC35
## Standard deviation  0.32974 0.31684 0.31578 0.2825 0.26595 0.17110 0.02476
## Proportion of Variance 0.00272 0.00251 0.00249 0.0020 0.00177 0.00073 0.00002
## Cumulative Proportion 0.99043 0.99294 0.99544 0.9974 0.99920 0.99993 0.99995
##              PC36   PC37   PC38   PC39   PC40
```



```
## Standard deviation      0.02424 0.02309 0.02131 0.01725 0.01537
## Proportion of Variance 0.00001 0.00001 0.00001 0.00001 0.00001
## Cumulative Proportion  0.99996 0.99998 0.99999 0.99999 1.00000
```

```
players.pca
```

```
## Standard deviations (1, ..., p=40):
## [1] 3.83377955 2.93856918 2.05266852 1.53691680 1.08835880 1.00961824
## [7] 0.90009025 0.86204243 0.78771966 0.77919601 0.70933766 0.65328212
## [13] 0.63258668 0.60846598 0.57770338 0.54221174 0.51429299 0.49239947
## [19] 0.48927914 0.47318972 0.46759168 0.44502719 0.43328953 0.41573224
## [25] 0.39870516 0.37168578 0.35021909 0.34623930 0.32973604 0.31683982
## [31] 0.31578014 0.28249478 0.26595178 0.17109955 0.02475568 0.02424333
## [37] 0.02309057 0.02130687 0.01724809 0.01536760
##
## Rotation (n x k) = (40 x 40):
##
##          PC1          PC2          PC3          PC4
## age      -0.072480130 -0.158088643 -0.109438724  0.067600476
## height_cm  0.084067636 -0.149322851 -0.285803598 -0.105561386
## weight_kg  0.056073829 -0.164108806 -0.297001435 -0.128093574
## pace      -0.126651998  0.127882555  0.190950772 -0.413100323
## shooting  -0.234432762  0.043517932 -0.165412058  0.018940839
## passing   -0.230149538 -0.108150868  0.083062221  0.126264948
## preferred_foot  0.011075046  0.003301558 -0.076186578 -0.021290793
## weak_foot  -0.099160410  0.005497474 -0.039711158 -0.004484918
## dribbling  -0.247187111 -0.009581467  0.056335955 -0.022028845
## defending   0.046884878 -0.298372811  0.195762335  0.035580858
## physic     -0.016988231 -0.278893983 -0.134809034 -0.249199885
## attacking_crossing -0.196293389 -0.041276985  0.155540208  0.046233945
## attacking_finishing -0.217152080  0.085059010 -0.172621382 -0.004036602
## attacking_heading_accuracy -0.007646297 -0.206234755 -0.238116157 -0.180220832
## attacking_short_passing -0.190991016 -0.164360102  0.049847814  0.095019910
## attacking_volleys -0.213811528  0.040878478 -0.165775680  0.024577637
## skill_dribbling -0.237420763  0.017610286  0.037023598 -0.009661791
## skill_curve -0.223883457 -0.014418767  0.019694950  0.098323235
## skill_fk_accuracy -0.197704674 -0.028458330  0.003205815  0.195159313
## skill_long_passing -0.156821736 -0.179106416  0.115243122  0.174832601
## skill_ball_control -0.229523325 -0.071592773  0.002269056  0.014924414
## movement_acceleration -0.132525078  0.136411566  0.207559147 -0.356035671
## movement_sprint_speed -0.114148589  0.112992460  0.165568164 -0.435104082
## movement_agility -0.180862395  0.100682175  0.194062410 -0.146436976
## movement_reactions -0.161647745 -0.193170408 -0.035375336 -0.072746725
## movement_balance -0.132459371  0.117952594  0.267745315  0.001698486
## power_shot_power -0.209554717 -0.040909351 -0.155664918  0.017190968
## power_jumping  0.002462086 -0.134138601 -0.040934175 -0.329495501
## power_stamina -0.098040896 -0.164236255  0.091453966 -0.236410244
## power_strength  0.025362250 -0.227424671 -0.253427467 -0.212568338
## power_long_shots -0.228079566  0.004837862 -0.112775439  0.067426578
## mentality_aggression -0.019927103 -0.272650430  0.018257689 -0.088457715
## mentality_interceptions  0.037481489 -0.287640790  0.204082864  0.048143798
## mentality_positioning -0.227442163  0.043817366 -0.073260553 -0.021289607
## mentality_vision -0.228644866 -0.036003314  0.013122239  0.123889545
## mentality_penalties -0.187041841  0.034343289 -0.196576193  0.058352867
## mentality_composure -0.183728190 -0.160437185 -0.056190813 -0.001371604
```

## defending_marking_awareness	0.042213214	-0.285058854	0.199241650	0.041344047
## defending_standing_tackle	0.053287374	-0.278767442	0.222232262	0.055315233
## defending_sliding_tackle	0.062330544	-0.269995153	0.232227840	0.047711475
##	PC5	PC6	PC7	
## age	0.2074990410	-0.450043583	0.141810647	
## height_cm	-0.2864886597	0.259817988	0.063462954	
## weight_kg	-0.2319196497	0.143607037	0.084185649	
## pace	-0.1139082974	0.085435782	0.038425469	
## shooting	0.0154959399	-0.031653602	-0.055571170	
## passing	-0.0714034029	0.073194573	0.006241189	
## preferred_foot	0.6384526763	0.513230759	-0.319084502	
## weak_foot	0.3300953495	0.290479196	0.864028568	
## dribbling	-0.0416583082	0.089593708	-0.066143387	
## defending	-0.0066760609	0.023244447	0.006110361	
## physic	0.0235669375	-0.074289007	0.012130131	
## attacking_crossing	-0.1612923425	-0.084796805	0.126058823	
## attacking_finishing	0.0214929017	-0.005841111	-0.070441598	
## attacking_heading_accuracy	0.0621454325	-0.043175786	-0.064601936	
## attacking_short_passing	-0.0277949523	0.185745763	-0.090868659	
## attacking_volleys	0.0344907813	-0.062774139	-0.013693362	
## skill_dribbling	-0.0933289266	0.106680880	-0.053394027	
## skill_curve	-0.0839950945	-0.087251366	0.100583812	
## skill_fk_accuracy	-0.0388252409	-0.141824308	0.151934912	
## skill_long_passing	-0.0325375758	0.165293246	-0.021357282	
## skill_ball_control	-0.0563477429	0.146892151	-0.088269874	
## movement_acceleration	-0.0777764108	0.059567652	0.028009684	
## movement_sprint_speed	-0.1367242046	0.101133829	0.045266081	
## movement_agility	0.0782665798	-0.058999564	0.002846191	
## movement_reactions	0.0424206651	0.025483452	-0.101668698	
## movement_balance	0.2413157007	-0.169056852	-0.054739123	
## power_shot_power	-0.0094560338	-0.030043634	-0.044928925	
## power_jumping	0.3341712484	-0.321040124	-0.021827868	
## power_stamina	0.0810170937	-0.090930864	-0.030965662	
## power_strength	-0.0736495337	-0.006062770	0.051456370	
## power_long_shots	0.0114251085	-0.057308117	-0.028613329	
## mentality_aggression	0.0981037911	-0.089219872	-0.039232789	
## mentality_interceptions	0.0051121741	0.005740453	0.009289499	
## mentality_positioning	-0.0102546529	-0.036499995	-0.063042425	
## mentality_vision	-0.0179767170	0.091011092	-0.050081775	
## mentality_penalties	0.0552695885	-0.110206636	-0.001263005	
## mentality_composure	0.0250958054	0.055972424	-0.042642698	
## defending_marking_awareness	-0.0007908089	0.020222716	0.017484702	
## defending_standing_tackle	-0.0260532375	0.042981547	0.005162027	
## defending_sliding_tackle	-0.0285936100	0.032816317	0.011200146	
##	PC8	PC9	PC10	
## age	-0.211016998	0.544122493	-0.4110510305	
## height_cm	-0.014102914	-0.057450146	-0.0785341226	
## weight_kg	-0.105336943	0.063459384	-0.1438347035	
## pace	-0.048414661	-0.038491453	-0.1987755871	
## shooting	-0.061854231	-0.157996946	0.0518879947	
## passing	-0.005675964	0.064030587	-0.0223917998	
## preferred_foot	-0.306681748	-0.008638958	-0.3017514673	
## weak_foot	0.107781268	-0.001364924	0.1477543746	
## dribbling	0.131153439	0.142387654	0.0559144414	

## defending	0.002918915	-0.126680999	-0.0735366977
## physic	-0.213229892	0.029444076	0.1996211261
## attacking_crossing	-0.122731693	0.131003304	-0.1972987641
## attacking_finishing	-0.037979836	-0.077809065	0.0881584020
## attacking_heading_accuracy	0.367055881	-0.053132161	-0.1091866529
## attacking_short_passing	0.171817314	0.138077955	0.0589703224
## attacking_volleys	-0.009837571	-0.160441433	-0.0754496299
## skill_dribbling	0.083719915	0.120415139	0.0636947528
## skill_curve	-0.103052724	-0.165476934	-0.1623585498
## skill_fk_accuracy	-0.182917819	-0.309919471	-0.2026194519
## skill_long_passing	0.039212258	0.043066651	0.0400013567
## skill_ball_control	0.197327623	0.167412649	0.0617689726
## movement_acceleration	-0.048274395	-0.033338403	-0.1576209494
## movement_sprint_speed	-0.045627776	-0.040340587	-0.2204218842
## movement_agility	-0.011173320	0.078659395	0.0001242502
## movement_reactions	0.226532444	0.173481903	-0.0138172634
## movement_balance	0.088321142	-0.013843913	0.1033240140
## power_shot_power	-0.059671925	-0.289701756	-0.0160372781
## power_jumping	0.381192664	-0.231323058	0.0120289933
## power_stamina	-0.425200765	0.082369606	0.5446098719
## power_strength	-0.156284243	0.080833069	0.0352806964
## power_long_shots	-0.125010015	-0.221834394	0.0569709341
## mentality_aggression	-0.050313257	-0.113054774	0.0715847715
## mentality_interceptions	-0.037098868	-0.108401237	-0.0546502987
## mentality_positioning	-0.077045816	0.081965339	0.1124981392
## mentality_vision	-0.059997794	0.041732408	0.1205599329
## mentality_penalties	0.037558952	-0.199484262	-0.1236531525
## mentality_composure	0.218977840	0.153250609	-0.0623103443
## defending_marking_awareness	-0.019417835	-0.085766306	-0.0759528568
## defending_standing_tackle	-0.023386658	-0.154179525	-0.0584484643
## defending_sliding_tackle	-0.010478059	-0.153469794	-0.0779809605
##	PC11	PC12	PC13
## age	0.0648181750	-0.0225170577	-0.054243709
## height_cm	-0.1108972591	-0.1076839278	0.079490495
## weight_kg	-0.1972993153	0.1046234885	-0.036988651
## pace	0.0566194207	-0.0169591408	-0.099854486
## shooting	0.1057546423	0.0103217850	0.061784938
## passing	-0.2009603863	-0.0502229976	-0.008247429
## preferred_foot	-0.0748282417	-0.0381375494	0.104308950
## weak_foot	0.0992472898	0.0199876769	0.038535026
## dribbling	0.0058879033	0.0891868911	0.133326176
## defending	0.1211543301	-0.0619268684	0.073907770
## physic	-0.0616664659	0.1576282281	-0.062105501
## attacking_crossing	-0.1181780545	-0.0948769908	0.446715720
## attacking_finishing	0.1220823008	-0.0424969095	0.116541655
## attacking_heading_accuracy	0.2353861852	-0.1942689828	0.063325022
## attacking_short_passing	-0.1496391988	-0.0618609322	-0.233904079
## attacking_volleys	0.1306187956	-0.0140943019	0.013458006
## skill_dribbling	-0.0001740911	0.0981551438	0.285671288
## skill_curve	-0.1327612321	0.0121520644	0.078247479
## skill_fk_accuracy	-0.1776769699	-0.0944721856	-0.228813726
## skill_long_passing	-0.3277121803	-0.0249338199	-0.294977156
## skill_ball_control	0.0091838435	0.0260448282	0.037402802
## movement_acceleration	0.0425966473	0.0024426036	-0.089123217

## movement_sprint_speed	0.0657839418	-0.0322544515	-0.103043760	
## movement_agility	-0.1070478598	0.1562398894	-0.062476835	
## movement_reactions	0.2662002372	-0.1395490974	-0.111462472	
## movement_balance	-0.0135828834	0.1915245091	-0.188764134	
## power_shot_power	0.0715558611	0.1776954574	-0.103555203	
## power_jumping	-0.5506642983	-0.1339495273	0.224589334	
## power_stamina	0.0540327517	-0.4477942158	-0.085896762	
## power_strength	-0.1405995527	0.1688575204	-0.089237027	
## power_long_shots	0.0352595935	0.0496252463	0.044423749	
## mentality_aggression	0.1660043128	0.6469777373	0.022936241	
## mentality_interceptions	0.1039412958	-0.0502064996	0.067667408	
## mentality_positioning	0.1087912800	-0.0002397462	0.393189789	
## mentality_vision	-0.1599165445	0.0225729672	0.042589863	
## mentality_penalties	0.1950825129	-0.2646072736	-0.221753401	
## mentality_composure	0.0944755520	0.0511355901	-0.234490543	
## defending_marking_awareness	0.1030832309	-0.0639630273	0.035576101	
## defending_standing_tackle	0.1059261465	-0.0366014270	0.087291715	
## defending_sliding_tackle	0.0994939764	-0.0257810664	0.109341493	
##	PC14	PC15	PC16	PC17
## age	0.27374048	-0.102793266	0.066903205	0.086510210
## height_cm	-0.09797467	-0.145458515	0.241611579	0.134934822
## weight_kg	-0.15901232	-0.361890580	-0.354985621	0.020422952
## pace	0.11688144	0.055199747	0.020786146	0.054823096
## shooting	0.19059590	-0.124608945	-0.023792939	0.003432707
## passing	0.05811345	0.156531656	-0.035320328	-0.013422387
## preferred_foot	-0.09954807	0.044575426	-0.004494695	-0.061561061
## weak_foot	0.04379009	-0.006239571	-0.011495560	0.001644189
## dribbling	-0.10749920	-0.077774420	-0.060016225	0.006842545
## defending	0.04161819	-0.119101997	-0.058160902	0.025821151
## physic	-0.06912401	0.123235500	-0.079893130	-0.027949836
## attacking_crossing	-0.14244854	0.263418428	-0.178689253	-0.251607746
## attacking_finishing	0.16776794	-0.118181308	-0.053834114	0.106081865
## attacking_heading_accuracy	0.06513928	0.303085179	-0.135973928	-0.414552957
## attacking_short_passing	0.17646326	0.127966283	-0.082289040	-0.012159342
## attacking_volleys	-0.03622205	-0.091840918	0.059579359	-0.048538975
## skill_dribbling	-0.07095876	-0.020240166	-0.092428478	0.056273605
## skill_curve	-0.29572901	0.041961625	0.202995839	-0.212100160
## skill_fk_accuracy	-0.28102639	0.128624443	0.152891399	-0.029833772
## skill_long_passing	0.31738104	0.167580772	-0.060503945	0.022005748
## skill_ball_control	-0.05022027	-0.021310293	-0.062107270	-0.043206128
## movement_acceleration	0.04874316	-0.002463870	0.008421871	0.057259988
## movement_sprint_speed	0.16562159	0.099277156	0.029350700	0.048426532
## movement_agility	-0.13779817	-0.261827191	0.077541745	0.010224932
## movement_reactions	-0.19230396	-0.081043255	0.241589132	0.014392688
## movement_balance	-0.21449969	-0.245814680	-0.431508491	-0.199191651
## power_shot_power	0.29949993	-0.131404190	0.045579489	-0.345391169
## power_jumping	0.05212060	-0.084004356	0.096103341	0.169283778
## power_stamina	-0.11501111	0.021067513	0.084842143	-0.112841446
## power_strength	-0.01926222	0.012628430	-0.232235501	-0.107312774
## power_long_shots	0.25295170	-0.189350357	0.055528896	-0.072607916
## mentality_aggression	-0.09369542	0.400001142	0.143923608	0.223034972
## mentality_interceptions	0.03254962	-0.142037491	-0.009234052	0.094398023
## mentality_positioning	0.02625921	0.005864313	-0.018571617	0.210481686
## mentality_vision	0.10057003	0.011913363	0.096876984	0.287602014

## mentality_penalties	-0.21143762	0.191095237	-0.435754847	0.499704025
## mentality_composure	-0.27196562	-0.179663572	0.298602833	-0.027791599
## defending_marking_awareness	0.02201368	-0.171919554	-0.035024075	0.028229523
## defending_standing_tackle	0.04765362	-0.121998586	-0.072115717	0.061736926
## defending_sliding_tackle	0.05672153	-0.098644365	-0.089689820	0.035365257
##	PC18	PC19	PC20	PC21
## age	-0.081590058	-0.116863325	-0.043216394	-0.069985271
## height_cm	0.078187625	-0.417691990	-0.041741372	-0.005218364
## weight_kg	0.227349266	-0.030373268	-0.012844804	-0.378096822
## pace	0.033522019	0.067495318	-0.007666205	-0.009823097
## shooting	0.017258734	0.017789900	0.016039730	-0.001878059
## passing	0.132512428	-0.010642238	0.014614316	0.015975125
## preferred_foot	-0.025773923	0.010370338	-0.014893833	-0.011359737
## weak_foot	0.005411246	0.016217209	-0.004243752	-0.017689765
## dribbling	-0.287734535	-0.034153615	-0.042064927	-0.058181488
## defending	-0.028579672	-0.005894702	0.042616766	0.058374713
## physic	-0.078185774	0.115399424	0.047372250	0.145996710
## attacking_crossing	0.209557829	-0.004842780	-0.233354199	0.015556373
## attacking_finishing	0.066657774	0.031278225	0.137588078	0.043865065
## attacking_heading_accuracy	0.029187647	-0.293676678	0.341898505	0.072763797
## attacking_short_passing	0.019581009	-0.026117045	0.012445767	-0.103267616
## attacking_volleys	0.286751572	-0.126304902	-0.054073511	0.158356358
## skill_dribbling	-0.346626470	0.013621241	-0.092413120	-0.071313114
## skill_curve	0.027243837	0.013879816	-0.049872975	0.113966425
## skill_fk_accuracy	-0.235703767	0.139495403	0.371212723	-0.231686244
## skill_long_passing	0.137548001	-0.139336220	-0.003957622	0.021830694
## skill_ball_control	-0.353368377	0.019099336	-0.077910449	-0.137427277
## movement_acceleration	0.013144309	0.017361896	0.027565233	-0.025731066
## movement_sprint_speed	0.048443930	0.103742714	-0.037178159	0.004016032
## movement_agility	-0.191137812	-0.546254435	0.318191108	0.176501452
## movement_reactions	0.182774102	0.315574291	0.178965377	-0.391990412
## movement_balance	0.320943049	-0.039618693	0.049192398	-0.049794998
## power_shot_power	-0.103747232	-0.010947195	-0.365660281	-0.089297849
## power_jumping	-0.008287655	0.088446195	-0.140973423	-0.074147643
## power_stamina	0.003223269	-0.169432279	-0.172023645	-0.129080942
## power_strength	-0.174085150	0.331135662	0.202691955	0.391884776
## power_long_shots	-0.075742528	0.047083190	0.066052230	-0.103884317
## mentality_aggression	0.120813625	-0.198535570	-0.093237603	-0.233530557
## mentality_interceptions	-0.010574473	0.019938771	0.083673103	0.021960089
## mentality_positioning	0.208883224	0.109209037	0.247504083	0.053844999
## mentality_vision	0.240141843	0.051376921	0.203113613	0.200046237
## mentality_penalties	-0.133484339	-0.119325764	-0.238378968	0.101728996
## mentality_composure	0.118148943	0.138513961	-0.315184786	0.432426559
## defending_marking_awareness	-0.036425449	0.021251727	-0.011495778	0.070131858
## defending_standing_tackle	-0.036079854	0.013029448	0.011430443	0.057110606
## defending_sliding_tackle	-0.036424073	-0.004678850	-0.016211645	0.054507993
##	PC22	PC23	PC24	
## age	-0.126787983	0.1166499701	0.103499947	
## height_cm	-0.072284531	-0.0285630165	0.616828105	
## weight_kg	-0.120618834	0.0061246032	-0.448369311	
## pace	-0.060323359	0.0433438004	0.010124651	
## shooting	0.028229343	-0.0513877491	0.013236039	
## passing	0.031354540	-0.0522594575	0.008460544	
## preferred_foot	-0.003749997	-0.0211294959	0.010144286	

## weak_foot	0.007019237	-0.0077797714	-0.004121938
## dribbling	-0.054634084	0.0905024143	0.020654953
## defending	-0.011540565	0.0256958076	-0.011607317
## physic	0.090169315	0.0214357826	0.075920348
## attacking_crossing	0.251115386	-0.3530065729	0.067604670
## attacking_finishing	0.030619239	0.0310209893	0.008134210
## attacking_heading_accuracy	-0.277266399	-0.0242588476	-0.129937596
## attacking_short_passing	0.134409177	0.1238759675	0.035791301
## attacking_volleys	0.413621966	0.5799349800	-0.073074760
## skill_dribbling	-0.141319244	0.1436023137	-0.004751115
## skill_curve	-0.094366965	0.3351004489	-0.085121199
## skill_fk_accuracy	-0.172466226	-0.0337290518	0.050051279
## skill_long_passing	0.060308392	0.0500564816	-0.064142730
## skill_ball_control	-0.012520072	0.2067266779	0.087768371
## movement_acceleration	0.026450021	0.0377334701	-0.021267372
## movement_sprint_speed	-0.128051959	0.0445626851	0.035301408
## movement_agility	0.320475197	-0.2905429279	-0.205497498
## movement_reactions	0.369415256	-0.1892258371	0.118156900
## movement_balance	-0.232575997	0.0589852767	0.457589425
## power_shot_power	-0.030999938	-0.2572013048	0.061504250
## power_jumping	0.025038034	0.0123950496	-0.010002485
## power_stamina	-0.114662459	0.0594554708	-0.094964834
## power_strength	0.200392097	0.0004990454	0.175707218
## power_long_shots	0.010262709	-0.1841882384	0.006608124
## mentality_aggression	-0.024229312	0.0135247725	-0.034960574
## mentality_interceptions	0.028306262	0.0029593285	0.026555819
## mentality_positioning	-0.179629051	-0.0180032726	-0.017795320
## mentality_vision	-0.284209059	-0.1109899932	-0.030719295
## mentality_penalties	0.074893155	-0.1527466774	0.009402666
## mentality_composure	-0.260959198	-0.2005497867	-0.188806728
## defending_marking_awareness	0.024539854	0.0139562711	0.001737209
## defending_standing_tackle	-0.009131944	0.0521840713	-0.014777004
## defending_sliding_tackle	-0.028303485	0.0340977981	-0.031763980
##	PC25	PC26	PC27
## age	-0.024196283	-0.0068015005	-0.005096509
## height_cm	0.036202109	0.0550050608	0.026633396
## weight_kg	0.003567332	-0.0207347951	-0.026550693
## pace	0.008298937	-0.0010865207	-0.020751677
## shooting	0.084060958	0.1507423359	-0.097286453
## passing	-0.018846111	-0.0449683281	-0.068555353
## preferred_foot	0.002392784	0.0091218084	0.001309075
## weak_foot	-0.018039072	0.0004362885	0.007616465
## dribbling	0.018385305	-0.0691101109	0.031903470
## defending	-0.005964802	-0.0072389232	-0.010609546
## physic	-0.002075012	0.0032358456	-0.007635103
## attacking_crossing	0.189724705	-0.0507083554	-0.122400201
## attacking_finishing	0.207254026	0.3248931050	-0.210620954
## attacking_heading_accuracy	-0.031080707	-0.0564442577	-0.050293818
## attacking_short_passing	0.045415043	0.1437612325	-0.058798372
## attacking_volleys	0.222640568	-0.3739017272	0.072914021
## skill_dribbling	0.001769002	-0.0951279140	0.155659213
## skill_curve	-0.570945436	0.3975148233	-0.105527487
## skill_fk_accuracy	0.369102500	-0.1467495183	0.139833299
## skill_long_passing	0.033219986	0.2229274085	0.289210475

## skill_ball_control	0.062964720	-0.0790722079	-0.220033306
## movement_acceleration	-0.011166004	0.0625484693	0.012774833
## movement_sprint_speed	0.024045266	-0.0539734571	-0.046062638
## movement_agility	-0.074180850	0.0043109231	0.064448635
## movement_reactions	-0.253209163	-0.0145572715	0.069430664
## movement_balance	0.015749972	0.0214888264	-0.014923683
## power_shot_power	-0.244441319	-0.2534113359	0.357867336
## power_jumping	0.029042866	-0.0067350162	0.005465657
## power_stamina	0.033534211	-0.0319336432	-0.004646979
## power_strength	-0.051947601	-0.0072534105	0.033379217
## power_long_shots	0.084286833	0.1712295577	-0.394630338
## mentality_aggression	0.074131763	0.0569917194	-0.099481023
## mentality_interceptions	-0.014685542	-0.0207406503	-0.039351559
## mentality_positioning	0.009379668	0.1886407676	0.565804167
## mentality_vision	-0.299016788	-0.5414803602	-0.279048494
## mentality_penalties	-0.180909927	0.0324587552	0.010802871
## mentality_composure	0.331616921	0.1159258607	0.006965070
## defending_marking_awareness	-0.077860854	-0.0247891636	-0.082323598
## defending_standing_tackle	0.057699091	0.0262592638	0.052031123
## defending_sliding_tackle	0.040833166	0.0078402008	0.097707414
##	PC28	PC29	PC30
## age	-0.009299312	-0.0279831650	0.0506117950
## height_cm	-0.015095366	-0.0372214349	-0.0076979068
## weight_kg	0.024759901	0.0178917158	0.0078265086
## pace	0.001044386	-0.0154254759	-0.0134712378
## shooting	-0.007104811	0.0332293675	0.0883488767
## passing	0.082281380	-0.0108972096	0.0243604958
## preferred_foot	-0.007772790	0.0023733098	-0.0004962666
## weak_foot	0.011856308	-0.0027508592	0.0074405890
## dribbling	-0.145240892	0.0118135128	-0.0104267843
## defending	0.025931675	0.0155521642	-0.0544870349
## physic	-0.016223632	-0.0082780497	0.0090180319
## attacking_crossing	-0.003819959	-0.0023107632	0.0098418342
## attacking_finishing	-0.012117902	0.1130054155	0.3009882892
## attacking_heading_accuracy	-0.074902026	-0.0648974175	-0.0273944089
## attacking_short_passing	0.498935887	0.0019971045	0.0209750838
## attacking_volleys	-0.058379277	-0.0085704919	-0.0759718800
## skill_dribbling	-0.418099590	-0.0223602472	-0.0411720220
## skill_curve	0.016124388	0.0443645910	0.0658837833
## skill_fk_accuracy	0.050377612	0.0202546364	0.0028856065
## skill_long_passing	-0.458035085	0.0086135640	-0.0958656039
## skill_ball_control	0.306354837	0.0163675858	0.0104679907
## movement_acceleration	0.053826222	-0.7497496003	-0.0456312950
## movement_sprint_speed	-0.043502935	0.5896077908	0.0131433528
## movement_agility	0.081575551	0.1465292200	0.0534957976
## movement_reactions	-0.201405335	0.0334526916	0.0795154075
## movement_balance	-0.050655058	0.0236211216	-0.0045883853
## power_shot_power	0.179856386	-0.0023140498	0.0856411954
## power_jumping	0.025483155	0.0062580291	0.0066379801
## power_stamina	-0.009594115	0.0042056449	0.0223276526
## power_strength	-0.030860828	-0.0217829568	0.0112367466
## power_long_shots	-0.201889499	-0.1112406892	-0.3024542982
## mentality_aggression	0.015495906	0.0114972297	-0.0194980671
## mentality_interceptions	-0.017016256	-0.0426920380	0.0096543593

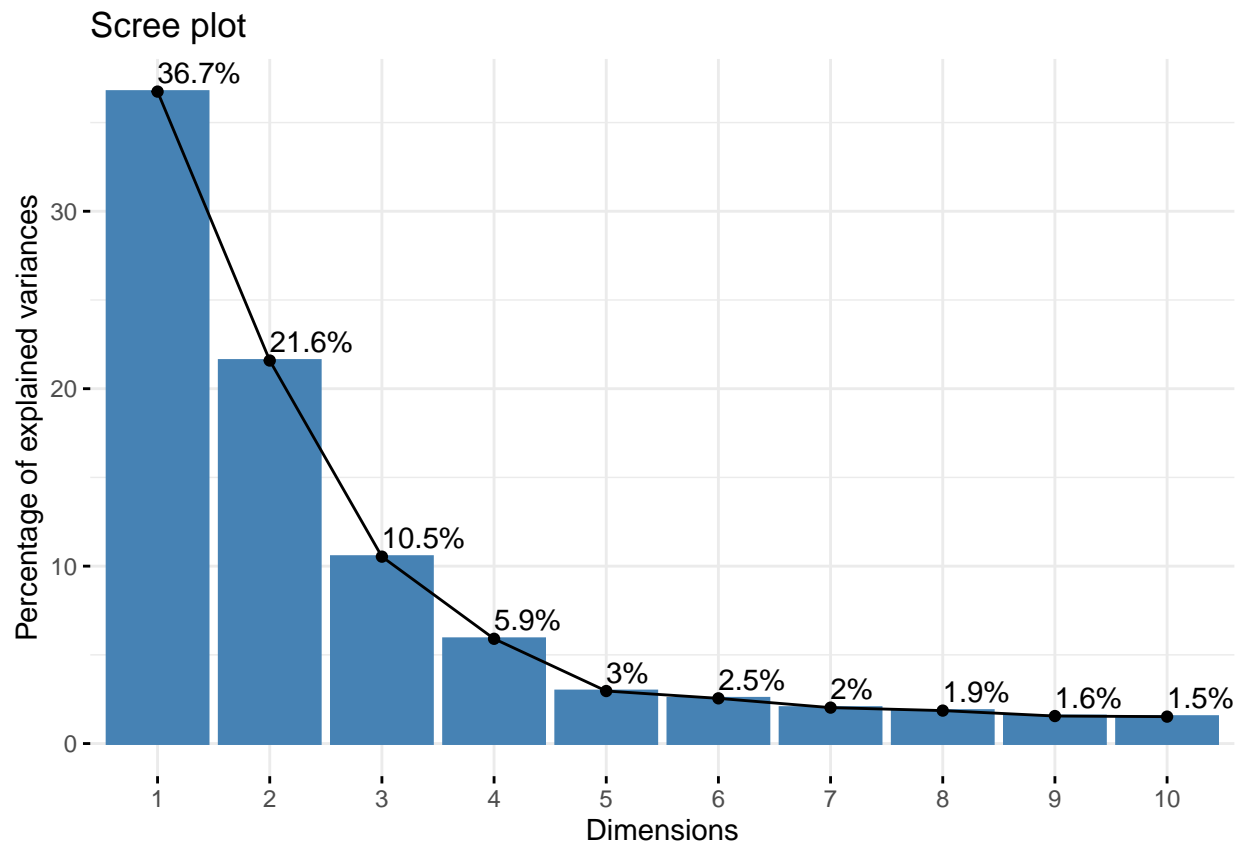
## mentality_positioning	0.296023812	0.0189195251	-0.2050046973
## mentality_vision	-0.014888417	-0.0682170504	0.1059012247
## mentality_penalties	-0.011666752	-0.0009053154	-0.0335113944
## mentality_composure	-0.004347297	-0.0413067847	-0.0123465348
## defending_marking_awareness	0.106656678	0.1363631249	-0.6678047329
## defending_standing_tackle	0.013620890	-0.0293373395	0.3455297608
## defending_sliding_tackle	-0.034266828	-0.0367738552	0.3758177098
##	PC31	PC32	PC33
## age	0.0032229406	0.0269229530	-0.0215156634
## height_cm	0.0159974587	0.0244584114	-0.0224584557
## weight_kg	-0.0051549029	-0.0178159940	0.0152522273
## pace	0.0074842111	-0.0109169305	0.0008610732
## shooting	-0.1574492898	0.0160895866	0.0188831556
## passing	0.0065624906	0.0900646284	0.0232532359
## preferred_foot	0.0093757459	-0.0025008775	-0.0017868682
## weak_foot	0.0059651751	0.0021172000	0.0001127599
## dribbling	-0.0117201840	0.0411427784	0.0243014785
## defending	-0.0479129823	0.0069801440	0.0123809977
## physic	0.0010685885	0.0074226367	-0.0102401676
## attacking_crossing	-0.0462630429	-0.0496279058	0.0077693886
## attacking_finishing	-0.5277656668	0.0471562931	0.0716623166
## attacking_heading_accuracy	0.0007604831	0.0051682412	0.0133901937
## attacking_short_passing	0.1792724951	0.4831005387	0.1510168115
## attacking_volleys	0.0977538451	0.0032403894	-0.0099474052
## skill_dribbling	-0.0206881176	0.3976012275	0.1494308190
## skill_curve	0.0139173704	-0.0114336279	0.0119971978
## skill_fk_accuracy	-0.0941633242	0.0316818393	-0.0046835820
## skill_long_passing	-0.1016171926	-0.3077650937	-0.0748059906
## skill_ball_control	-0.0191146918	-0.6151016937	-0.1819928181
## movement_acceleration	-0.1478954396	-0.0030848264	-0.0216591120
## movement_sprint_speed	0.1359605807	-0.0158706376	0.0210322965
## movement_agility	0.0237447301	0.0022086152	-0.0194990328
## movement_reactions	-0.0196292085	0.0093792685	-0.0819209942
## movement_balance	0.0214457488	0.0061611590	-0.0024733553
## power_shot_power	-0.1283117682	-0.0131553657	0.0706063013
## power_jumping	-0.0133024053	0.0001657067	-0.0041811998
## power_stamina	0.0005951523	0.0098610122	-0.0053791303
## power_strength	0.0214262239	0.0038865810	-0.0095686735
## power_long_shots	0.5460691793	0.0083840204	-0.1231758593
## mentality_aggression	-0.0439380958	0.0037425457	-0.0103416263
## mentality_interceptions	0.0965749328	-0.2622169231	0.8075813321
## mentality_positioning	0.1897803370	-0.1365742576	-0.0550292693
## mentality_vision	-0.0687386784	-0.0015415432	-0.0608198029
## mentality_penalties	0.0802912462	-0.0255023226	-0.0090174590
## mentality_composure	0.0443463658	0.0118202204	0.0280689866
## defending_marking_awareness	-0.4163625640	0.1461382844	-0.2001574057
## defending_standing_tackle	0.1426604037	0.0309843104	-0.1956148030
## defending_sliding_tackle	0.1361147863	0.0798802457	-0.3755444864
##	PC34	PC35	PC36
## age	-8.306152e-03	1.419163e-04	5.447552e-04
## height_cm	5.894229e-03	-2.653739e-04	-3.960487e-04
## weight_kg	-1.160044e-03	-6.265546e-04	7.664304e-04
## pace	-6.361779e-04	-1.274037e-02	3.052840e-04
## shooting	9.491810e-03	-4.505019e-03	5.034353e-04

## passing	1.312630e-03	8.392116e-01	2.738262e-01
## preferred_foot	1.611146e-03	3.096195e-05	-8.824454e-05
## weak_foot	9.925979e-05	-2.478296e-05	-4.434481e-04
## dribbling	-4.845698e-03	2.571182e-01	-7.918862e-01
## defending	-1.231920e-01	1.515114e-02	7.086214e-03
## physic	5.787596e-03	3.969797e-02	-8.454382e-02
## attacking_crossing	-1.695611e-02	-2.253414e-01	-7.366463e-02
## attacking_finishing	2.227564e-02	3.284655e-03	1.266658e-04
## attacking_heading_accuracy	-9.833473e-03	-9.200295e-04	-5.265444e-04
## attacking_short_passing	3.074068e-02	-2.732081e-01	-8.894828e-02
## attacking_volleys	7.541373e-03	6.081649e-04	-2.095080e-04
## skill_dribbling	-1.977685e-02	-1.428303e-01	4.421798e-01
## skill_curve	1.939743e-03	-6.096109e-02	-2.029659e-02
## skill_fk_accuracy	8.474875e-03	-5.996069e-02	-1.939704e-02
## skill_long_passing	-1.840355e-02	-1.475462e-01	-4.799349e-02
## skill_ball_control	1.786313e-02	-7.659951e-02	2.350175e-01
## movement_acceleration	-6.174309e-03	6.582277e-03	-7.102640e-04
## movement_sprint_speed	2.720745e-04	7.387960e-03	1.646961e-04
## movement_agility	-1.451642e-03	-3.171278e-02	9.617039e-02
## movement_reactions	-3.668902e-03	-1.208176e-02	3.613795e-02
## movement_balance	-1.412071e-03	-1.592432e-02	4.758679e-02
## power_shot_power	-1.732972e-02	7.778780e-04	-3.840475e-04
## power_jumping	-6.356203e-03	-2.471331e-03	4.929214e-03
## power_stamina	5.656056e-03	-1.159907e-02	2.432269e-02
## power_strength	6.703399e-03	-2.546401e-02	5.414058e-02
## power_long_shots	5.618993e-03	5.872987e-04	-4.776393e-04
## mentality_aggression	-3.608349e-03	-1.101687e-02	2.412792e-02
## mentality_interceptions	1.504396e-01	-3.392425e-03	-1.907913e-03
## mentality_positioning	2.518011e-03	2.371028e-05	-7.281182e-04
## mentality_vision	-3.857418e-03	-2.101850e-01	-6.935275e-02
## mentality_penalties	4.173378e-05	2.642994e-04	-1.976372e-05
## mentality_composure	8.503206e-03	-1.381324e-02	4.209192e-02
## defending_marking_awareness	3.223464e-02	-4.042443e-03	-2.125350e-03
## defending_standing_tackle	-7.107383e-01	-5.420381e-03	-3.185984e-03
## defending_sliding_tackle	6.724049e-01	-1.524657e-03	-1.018934e-04
##	PC37	PC38	PC39
## age	6.274190e-04	8.954042e-05	4.228375e-06
## height_cm	4.767757e-04	3.396953e-05	3.313422e-04
## weight_kg	2.563492e-04	-2.550043e-05	-2.618686e-04
## pace	8.824902e-03	8.054941e-01	1.315123e-02
## shooting	5.365575e-03	1.384346e-02	-8.551124e-01
## passing	-1.248218e-02	1.357196e-02	-3.549770e-03
## preferred_foot	3.814775e-05	-1.924334e-04	-6.030900e-05
## weak_foot	-3.043319e-04	2.308816e-04	-1.646912e-04
## dribbling	-9.760066e-02	5.646372e-03	-2.218997e-03
## defending	-1.698856e-02	-1.229994e-03	-5.072468e-02
## physic	7.890150e-01	-7.935395e-03	3.716145e-03
## attacking_crossing	3.736665e-03	-3.383119e-03	9.937947e-04
## attacking_finishing	-3.070224e-03	-7.820585e-03	4.435919e-01
## attacking_heading_accuracy	1.210543e-03	5.121430e-04	3.879893e-03
## attacking_short_passing	3.317183e-03	-4.516258e-03	6.327319e-04
## attacking_volleys	1.127191e-03	-4.962838e-04	4.459779e-02
## skill_dribbling	5.405384e-02	-2.658769e-03	1.809638e-03
## skill_curve	6.320248e-06	-1.267081e-03	3.703898e-04

## skill_fk_accuracy	8.176676e-04	-1.123562e-03	-1.223495e-05
## skill_long_passing	2.642970e-03	-2.396241e-03	9.701049e-04
## skill_ball_control	2.945786e-02	-2.401239e-03	5.254751e-04
## movement_acceleration	-3.366660e-03	-3.762547e-01	-5.845187e-03
## movement_sprint_speed	-5.162313e-03	-4.571153e-01	-7.740344e-03
## movement_agility	1.206171e-02	-6.075977e-04	4.949835e-04
## movement_reactions	4.894052e-03	-2.721143e-04	8.982270e-05
## movement_balance	5.415420e-03	-1.325435e-04	8.345551e-05
## power_shot_power	-9.191086e-04	-2.141886e-03	1.617442e-01
## power_jumping	-4.732150e-02	1.640362e-04	-2.849975e-04
## power_stamina	-2.245225e-01	2.602687e-03	-9.238518e-04
## power_strength	-5.101972e-01	4.988183e-03	-2.428862e-03
## power_long_shots	-1.062285e-03	-3.000798e-03	1.922216e-01
## mentality_aggression	-2.241107e-01	2.155191e-03	-9.791913e-04
## mentality_interceptions	3.703241e-03	6.012530e-04	1.123996e-02
## mentality_positioning	-7.538277e-04	-8.233088e-04	4.293953e-02
## mentality_vision	3.001892e-03	-3.847571e-03	6.994176e-04
## mentality_penalties	-5.099807e-04	-3.519901e-04	3.784370e-02
## mentality_composure	5.107380e-03	1.677906e-05	-3.277625e-05
## defending_marking_awareness	5.840566e-03	2.494857e-04	1.642182e-02
## defending_standing_tackle	6.512853e-03	1.494833e-03	1.756248e-02
## defending_sliding_tackle	1.348930e-03	-1.191140e-03	5.308509e-03
##	PC40		
## age	4.299615e-04		
## height_cm	7.604247e-05		
## weight_kg	-2.824716e-04		
## pace	2.574252e-03		
## shooting	-4.919064e-02		
## passing	-1.697139e-02		
## preferred_foot	-4.271658e-05		
## weak_foot	-5.934770e-05		
## dribbling	1.304617e-05		
## defending	8.782105e-01		
## physic	1.571308e-02		
## attacking_crossing	4.638870e-03		
## attacking_finishing	2.531876e-02		
## attacking_heading_accuracy	-6.356491e-02		
## attacking_short_passing	5.351924e-03		
## attacking_volleys	1.989017e-03		
## skill_dribbling	-1.111153e-04		
## skill_curve	1.293484e-03		
## skill_fk_accuracy	8.966773e-04		
## skill_long_passing	3.170157e-03		
## skill_ball_control	-2.866416e-04		
## movement_acceleration	-9.169701e-04		
## movement_sprint_speed	-1.413350e-03		
## movement_agility	-8.924522e-05		
## movement_reactions	6.027973e-06		
## movement_balance	3.914447e-05		
## power_shot_power	9.694846e-03		
## power_jumping	-1.327883e-03		
## power_stamina	-4.464160e-03		
## power_strength	-1.011599e-02		
## power_long_shots	1.112515e-02		

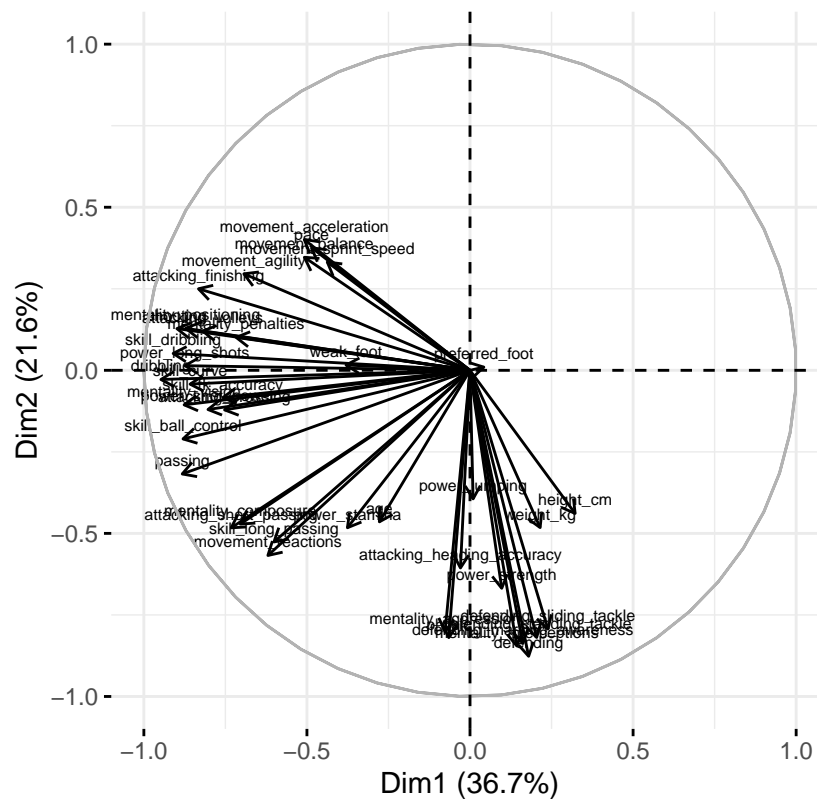
```
## mentality_aggression      -4.179971e-03
## mentality_interceptions   -2.013203e-01
## mentality_positioning      2.635429e-03
## mentality_vision           4.348487e-03
## mentality_penalties        2.252457e-03
## mentality_composure        2.430019e-04
## defending_marking_awareness -2.830734e-01
## defending_standing_tackle   -3.003296e-01
## defending_sliding_tackle    -9.891987e-02
```

```
fviz_eig(players.pca, addlabels = TRUE)
```



```
fviz_pca_var(players.pca, labelsize = 2, alpha.var = 1.0, title = "Factor Plane for the FIFA 22 Data")
```

Factor Plane for the FIFA 22 Data



```
#CLASSIFICATION
```

```
#CLASSIFICATION
```

train-test split

```
## 70% of the sample size
smp_size <- floor(0.7 * nrow(players_model))

## set the seed to make your partition reproducible
train_ind <- sample(seq_len(nrow(players_model)), size = smp_size)

train <- players_model[train_ind, ]
test <- players_model[-train_ind, ]

dim(test)

## [1] 3958 41
```

```
colnames(train)
```

```
## [1] "age" "height_cm"
## [3] "weight_kg" "pace"
## [5] "shooting" "passing"
## [7] "preferred_foot" "weak_foot"
## [9] "dribbling" "defending"
## [11] "physic" "attacking_crossing"
## [13] "attacking_finishing" "attacking_heading_accuracy"
## [15] "attacking_short_passing" "attacking_volleys"
## [17] "skill_dribbling" "skill_curve"
## [19] "skill_fk_accuracy" "skill_long_passing"
## [21] "skill_ball_control" "movement_acceleration"
## [23] "movement_sprint_speed" "movement_agility"
## [25] "movement_reactions" "movement_balance"
## [27] "power_shot_power" "power_jumping"
## [29] "power_stamina" "power_strength"
## [31] "power_long_shots" "mentality_aggression"
## [33] "mentality_interceptions" "mentality_positioning"
## [35] "mentality_vision" "mentality_penalties"
## [37] "mentality_composure" "defending_marking_awareness"
## [39] "defending_standing_tackle" "defending_sliding_tackle"
## [41] "player_positions"
```

We extract 'club_position' column of train dataset because it will be used as 'cl' argument in knn function.

```
#extract 39th column of train dataset (club_position) that will be used as 'cl' argument in knn function
```

```
train_y <- as.factor(train[,41])
```

```
#extract 18th column of test set to measure accuracy
```

```
test_y <- as.factor(test[,41])
```

```
##run knn function
```

```
class <- factor(c(train_y))
```

```
train <- train[1:(length(train)-1)]
```

```
test <- test[1:(length(test)-1)]
```

```
accuracy_vect <- c()
```

```
ks <- c()
```

```
accuracy <- function(x){sum(diag(x)/(sum(rowSums(x)))) * 100}
```

```
for(k1 in seq(5,100,5)) {
```

```
  test_pred <- knn(train = train, test = test, cl = class, k = k1)
```

```
  accuracy_vect <- append(accuracy_vect, accuracy(table(test_y, test_pred)))
```

```
  ks <- append(ks, k1)
```

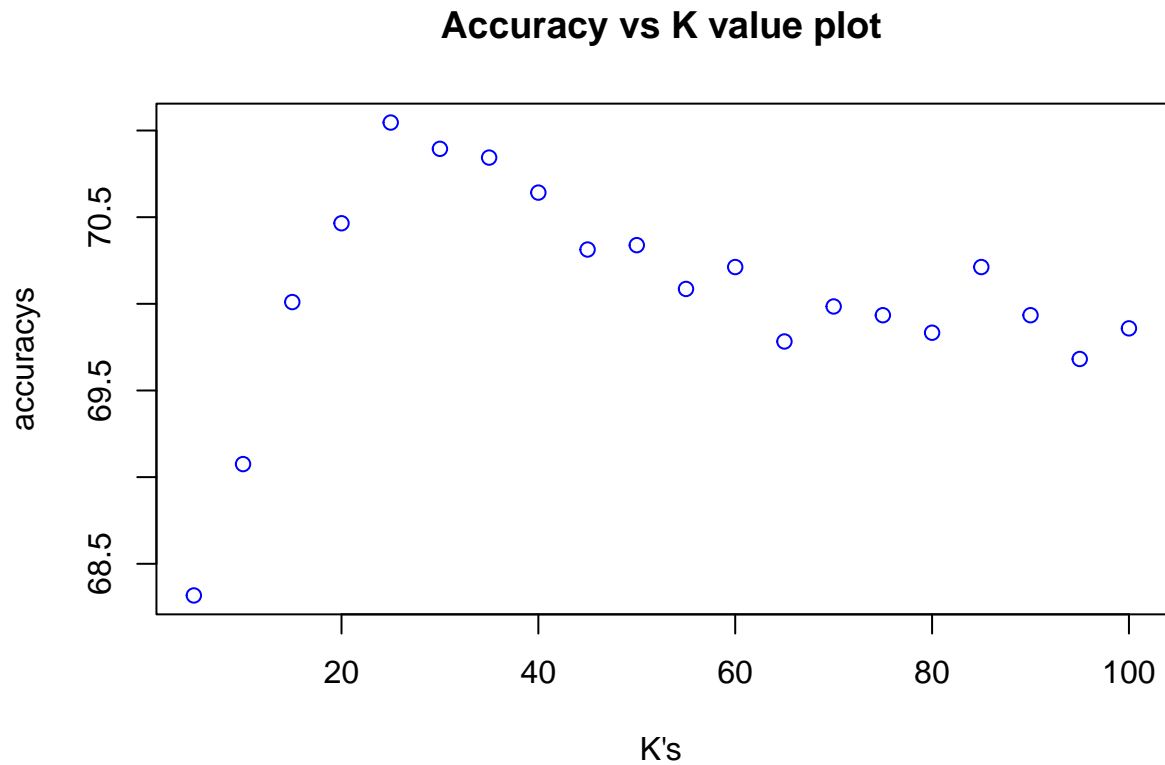
```
}
```

```
#accuracy_vect <- na.omit(accuracy_vect)
```

```
print(ks[which.max(accuracy_vect)])
```

```
## [1] 25
```

```
#test_pred <-knn(train = train, test = test, cl = class, k = 10)
#x = accuracy(table(test_y,test_pred)
#accuracy_vect
plot(ks, accuracy_vect, type = "p", col="blue", xlab="K's", ylab="accuracys", main="Accuracy vs K value
```



```
test_pred <-knn(train = train, test = test, cl = class, k = 20)
df_pred=data.frame(test_y,test_pred)
head(df_pred)
```

```
##   test_y test_pred
## 1     ST         ST
## 2     LW         LW
## 3     CDM        RB
## 4     ST         ST
## 5     ST         ST
## 6     CAM         CM
```

```
#Evaluate the model performance
```

```
CrossTable(x=test_y, y=test_pred,prop.chisq = FALSE)
```

```
##
##
##   Cell Contents
```

```

## |-----|
## |                N |
## |      N / Row Total |
## |      N / Col Total |
## |      N / Table Total |
## |-----|
##
##
## Total Observations in Table:  3958
##
##
##      | test_pred
## test_y |      CAM |      CB |      CDM |      CM |      LB |      LW |      RB |
## -----|-----|-----|-----|-----|-----|-----|-----|
##      CAM |      121 |        0 |        1 |       68 |        5 |       30 |        1 |
##           |      0.402 |      0.000 |      0.003 |      0.226 |      0.017 |      0.100 |      0.003 |
##           |      0.563 |      0.000 |      0.003 |      0.099 |      0.012 |      0.118 |      0.003 |
##           |      0.031 |      0.000 |      0.000 |      0.017 |      0.001 |      0.008 |      0.000 |
## -----|-----|-----|-----|-----|-----|-----|-----|
##      CB |        0 |      647 |       30 |        3 |       24 |        0 |       21 |
##           |      0.000 |      0.892 |      0.041 |      0.004 |      0.033 |      0.000 |      0.029 |
##           |      0.000 |      0.902 |      0.100 |      0.004 |      0.057 |      0.000 |      0.059 |
##           |      0.000 |      0.163 |      0.008 |      0.001 |      0.006 |      0.000 |      0.005 |
## -----|-----|-----|-----|-----|-----|-----|-----|
##      CDM |        0 |       36 |      211 |      115 |       14 |        0 |       15 |
##           |      0.000 |      0.092 |      0.540 |      0.294 |      0.036 |      0.000 |      0.038 |
##           |      0.000 |      0.050 |      0.703 |      0.167 |      0.033 |      0.000 |      0.042 |
##           |      0.000 |      0.009 |      0.053 |      0.029 |      0.004 |      0.000 |      0.004 |
## -----|-----|-----|-----|-----|-----|-----|-----|
##      CM |       25 |        3 |       39 |      393 |       13 |        2 |        0 |
##           |      0.052 |      0.006 |      0.081 |      0.817 |      0.027 |      0.004 |      0.000 |
##           |      0.116 |      0.004 |      0.130 |      0.571 |      0.031 |      0.008 |      0.000 |
##           |      0.006 |      0.001 |      0.010 |      0.099 |      0.003 |      0.001 |      0.000 |
## -----|-----|-----|-----|-----|-----|-----|-----|
##      LB |        0 |       14 |        1 |        9 |      326 |        0 |       18 |
##           |      0.000 |      0.038 |      0.003 |      0.024 |      0.886 |      0.000 |      0.049 |
##           |      0.000 |      0.020 |      0.003 |      0.013 |      0.780 |      0.000 |      0.051 |
##           |      0.000 |      0.004 |      0.000 |      0.002 |      0.082 |      0.000 |      0.005 |
## -----|-----|-----|-----|-----|-----|-----|-----|
##      LW |       26 |        0 |        2 |       24 |       29 |      108 |        1 |
##           |      0.074 |      0.000 |      0.006 |      0.068 |      0.083 |      0.308 |      0.003 |
##           |      0.121 |      0.000 |      0.007 |      0.035 |      0.069 |      0.425 |      0.003 |
##           |      0.007 |      0.000 |      0.001 |      0.006 |      0.007 |      0.027 |      0.000 |
## -----|-----|-----|-----|-----|-----|-----|-----|
##      RB |        0 |       17 |       15 |       29 |        2 |        0 |      286 |
##           |      0.000 |      0.048 |      0.043 |      0.083 |      0.006 |      0.000 |      0.815 |
##           |      0.000 |      0.024 |      0.050 |      0.042 |      0.005 |      0.000 |      0.803 |
##           |      0.000 |      0.004 |      0.004 |      0.007 |      0.001 |      0.000 |      0.072 |
## -----|-----|-----|-----|-----|-----|-----|-----|
##      RW |       32 |        0 |        0 |       36 |        5 |       80 |       14 |
##           |      0.092 |      0.000 |      0.000 |      0.104 |      0.014 |      0.231 |      0.040 |
##           |      0.149 |      0.000 |      0.000 |      0.052 |      0.012 |      0.315 |      0.039 |
##           |      0.008 |      0.000 |      0.000 |      0.009 |      0.001 |      0.020 |      0.004 |
## -----|-----|-----|-----|-----|-----|-----|-----|

```

##	ST		11		0		1		11		0		34		0	
##			0.017		0.000		0.002		0.017		0.000		0.053		0.000	
##			0.051		0.000		0.003		0.016		0.000		0.134		0.000	
##			0.003		0.000		0.000		0.003		0.000		0.009		0.000	
##	-----		-----		-----		-----		-----		-----		-----		-----	
##	Column Total		215		717		300		688		418		254		356	
##			0.054		0.181		0.076		0.174		0.106		0.064		0.090	
##	-----		-----		-----		-----		-----		-----		-----		-----	
##																
##																

##Plotting a better confusion matrix

```
#creating confusion matrix
conf_mat <- confusion_matrix(targets = test_y,
                             predictions = test_pred)
#plotting confusion matrix
plot_confusion_matrix(conf_mat$`Confusion Matrix`[[1]],
                      add_sums = TRUE)
```

```
## Warning in plot_confusion_matrix(conf_mat$`Confusion Matrix`[[1]], add_sums =
## TRUE): 'ggimage' is missing. Will not plot arrows and zero-shading.
```

```
## Warning in plot_confusion_matrix(conf_mat$`Confusion Matrix`[[1]], add_sums =
## TRUE): 'rsvg' is missing. Will not plot arrows and zero-shading.
```

```
## Warning in plot_confusion_matrix(conf_mat$`Confusion Matrix`[[1]], add_sums =
## TRUE): 'ggnewscale' is missing. Will not use palette for sum tiles.
```

```
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on 'â' in 'mbcsToSbcs': dot substituted for <e2>
```

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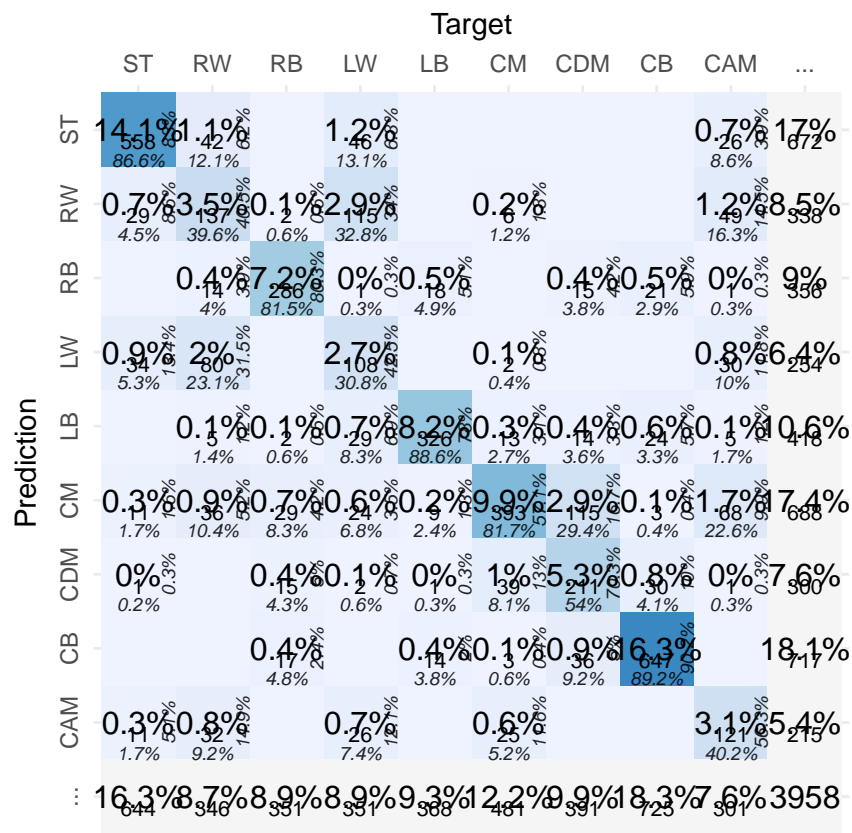
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
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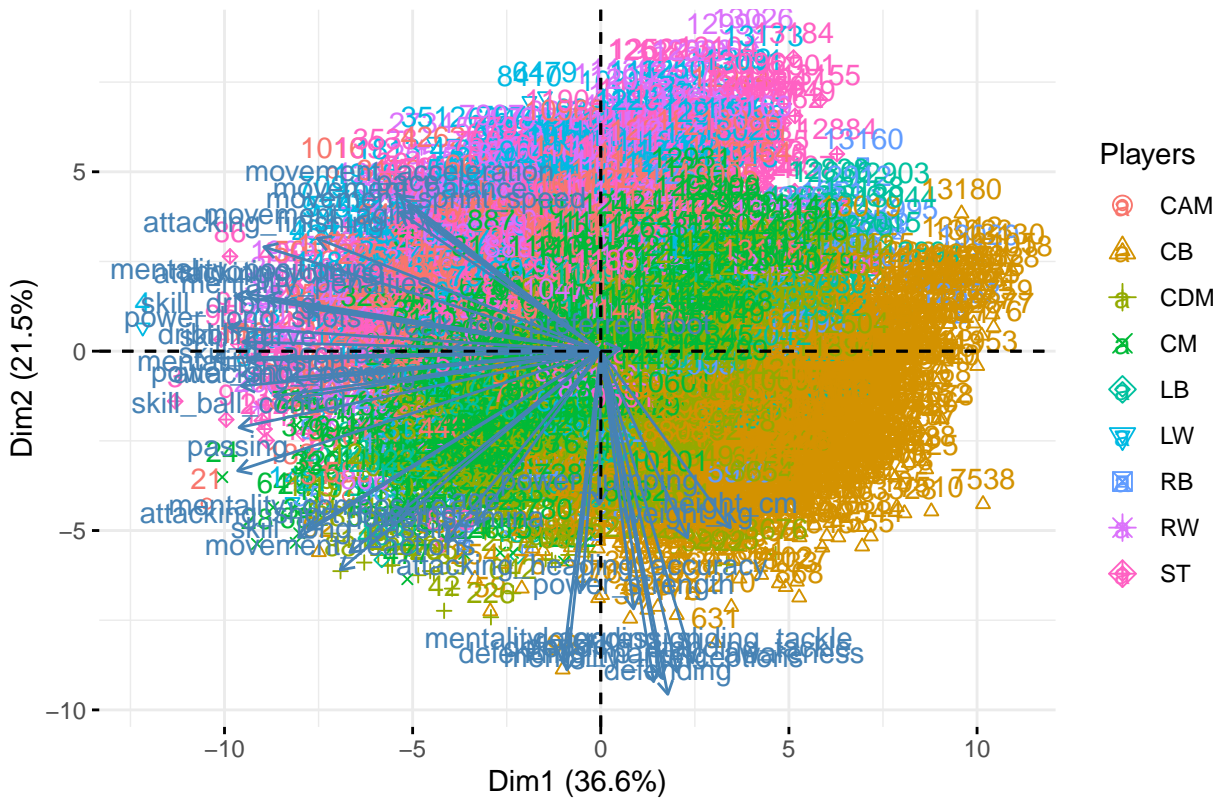


```
#test_pred[5]
#dif <- c()
#for(i in seq(1,length(test_y))){
# if test_pred[i]==y_pred[i] dif[i] <- 1 ### difference
# else dif[i] <- 0
#}
```

Plotting on pca main dimensions the categories

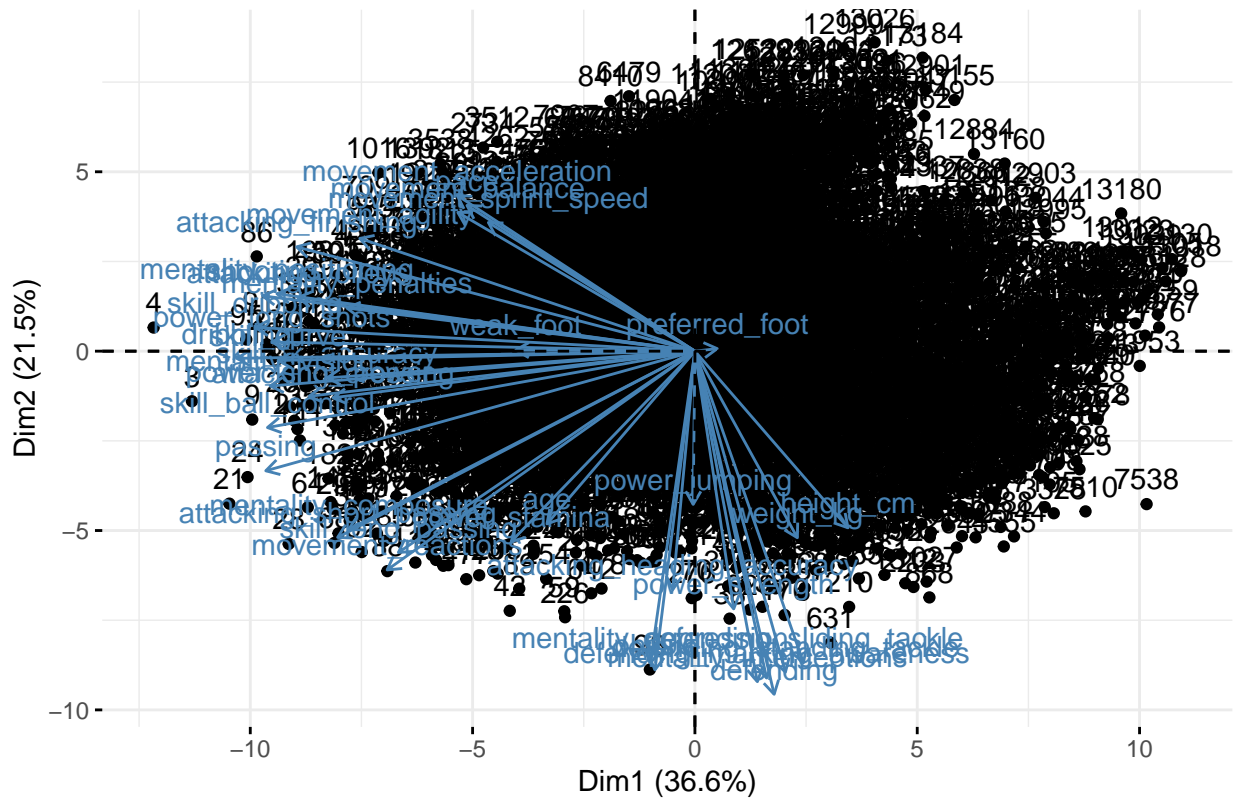
```
test.pca<-prcomp(test,center=TRUE, scale.=TRUE)
fviz_pca_biplot(test.pca,
  label = "all",
  col.ind = test_y,
  legend.title = "Players",
  title = "Classification of players")
```

Classification of players



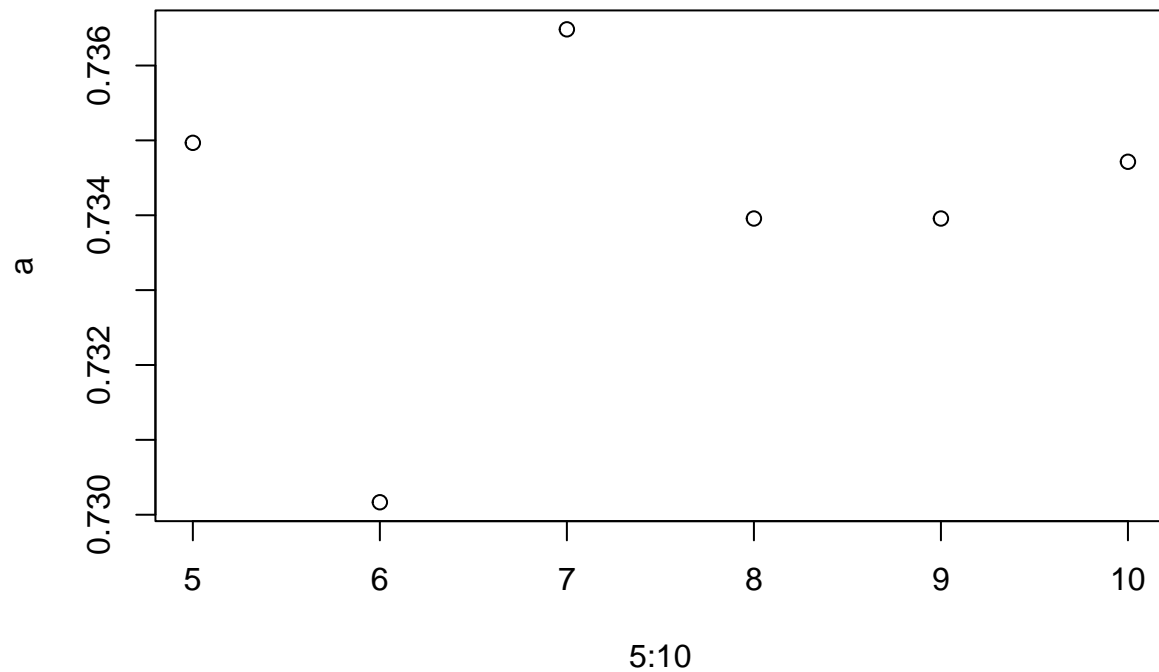
```
fviz_pca_biplot(test.pca,
  label = "all",
  col.ind = ,
  legend.title = "Players",
  title = "Classification of predicted players")
```

Classification of predicted players



Random Forrest

```
a=c()
i=5
for (i in 5:10) {
  model_RF <- randomForest(train_y ~ ., data = train, ntree = 500, mtry = i, importance = TRUE)
  prediction_RF <- predict(model_RF, test, type = "class")
  a[i-4] = mean(prediction_RF == test_y)
}
plot(5:10,a)
```

```
a
```

```
## [1] 0.7349672 0.7301668 0.7364831 0.7339565 0.7339565 0.7347145
```

a = 8 is the best one

SVM

```
library("class")
library("e1071")
```

```
## Warning: package 'e1071' was built under R version 4.2.1
```

```
svm1 <- svm(formula= train_y~., data=train,
            type="C-classification", kernel="radial",
            gamma=0.1, cost=10)
```

```
summary(svm1)
```

```
##
## Call:
## svm(formula = train_y ~ ., data = train, type = "C-classification",
```

```
##      kernal = "radial", gamma = 0.1, cost = 10)
##
##
## Parameters:
##   SVM-Type:  C-classification
##   SVM-Kernel: radial
##       cost:  10
##
## Number of Support Vectors:  7212
##
## ( 985 590 874 809 691 794 1063 811 595 )
##
##
## Number of Classes:  9
##
## Levels:
##   CAM CB CDM CM LB LW RB RW ST
```

```
#plot(svm1, train, train$shooting ~ train$space,
#      )
```

```
prediction <- predict(svm1,test, type = "class")

xtab <- table(test_y, prediction)
accuracy(xtab)
```

```
## [1] 71.77868
```

```
#####Group RW and LW
```

```
test_y2 <- test_y
levels(test_y2)[levels(test_y2) == "RW"| levels(test_y2) == "LW"] <- "W"
levels(test_y2)[levels(test_y2) == "CAM"| levels(test_y2) == "CM"] <- "CM"
unique(test_y2)
```

```
## [1] ST  W   CDM CM  RB  CB  LB
## Levels: CM CB CDM LB W RB ST
```

```
train_y2 <- train_y
levels(train_y2)[levels(train_y2) == "RW"| levels(train_y2) == "LW"] <- "W"
levels(train_y2)[levels(train_y2) == "CAM"| levels(train_y2) == "CM"] <- "CM"
```

```
#try RF
```

```
model_RF2 <- randomForest(train_y2 ~ ., data = train, ntree = 500, mtry = 8, importance = TRUE)
prediction_RF2 <- predict(model_RF2, test, type = "class")
accuracy(table(prediction_RF2, test_y2))
```

```
## [1] 80.87418
```

```
test_pred <-knn(train = train, test = test, cl = train_y2, k = 20)
CrossTable(x=test_y2, y=test_pred,prop.chisq = FALSE)
```

```
##
##
##   Cell Contents
## |-----|
## |                N |
## |      N / Row Total |
## |      N / Col Total |
## |      N / Table Total |
## |-----|
##
##
## Total Observations in Table:  3958
##
##
##      | test_pred
## test_y2 |      CM |      CB |      CDM |      LB |      W |      RB |      ST | R
## -----|-----|-----|-----|-----|-----|-----|-----|-----|
##      CM |      590 |       3 |      41 |      12 |     114 |       1 |      21 |
##      |      0.754 |     0.004 |     0.052 |     0.015 |     0.146 |     0.001 |     0.027 |
##      |      0.674 |     0.004 |     0.137 |     0.030 |     0.165 |     0.003 |     0.034 |
##      |      0.149 |     0.001 |     0.010 |     0.003 |     0.029 |     0.000 |     0.005 |
## -----|-----|-----|-----|-----|-----|-----|-----|
##      CB |       4 |     648 |      28 |      25 |       0 |      20 |       0 |
##      |     0.006 |     0.894 |     0.039 |     0.034 |     0.000 |     0.028 |     0.000 |
##      |     0.005 |     0.909 |     0.093 |     0.062 |     0.000 |     0.057 |     0.000 |
##      |     0.001 |     0.164 |     0.007 |     0.006 |     0.000 |     0.005 |     0.000 |
## -----|-----|-----|-----|-----|-----|-----|-----|
##      CDM |     117 |      32 |     213 |      15 |       0 |      14 |       0 |
##      |     0.299 |     0.082 |     0.545 |     0.038 |     0.000 |     0.036 |     0.000 |
##      |     0.134 |     0.045 |     0.710 |     0.037 |     0.000 |     0.040 |     0.000 |
##      |     0.030 |     0.008 |     0.054 |     0.004 |     0.000 |     0.004 |     0.000 |
## -----|-----|-----|-----|-----|-----|-----|-----|
##      LB |      11 |      14 |       1 |     324 |       1 |      17 |       0 |
##      |     0.030 |     0.038 |     0.003 |     0.880 |     0.003 |     0.046 |     0.000 |
##      |     0.013 |     0.020 |     0.003 |     0.798 |     0.001 |     0.048 |     0.000 |
##      |     0.003 |     0.004 |     0.000 |     0.082 |     0.000 |     0.004 |     0.000 |
## -----|-----|-----|-----|-----|-----|-----|-----|
##      W |     108 |       0 |       2 |      28 |     484 |      15 |      60 |
##      |     0.155 |     0.000 |     0.003 |     0.040 |     0.694 |     0.022 |     0.086 |
##      |     0.123 |     0.000 |     0.007 |     0.069 |     0.700 |     0.042 |     0.097 |
##      |     0.027 |     0.000 |     0.001 |     0.007 |     0.122 |     0.004 |     0.015 |
## -----|-----|-----|-----|-----|-----|-----|-----|
##      RB |      28 |      16 |      14 |       2 |       5 |     286 |       0 |
##      |     0.080 |     0.046 |     0.040 |     0.006 |     0.014 |     0.815 |     0.000 |
##      |     0.032 |     0.022 |     0.047 |     0.005 |     0.007 |     0.810 |     0.000 |
##      |     0.007 |     0.004 |     0.004 |     0.001 |     0.001 |     0.072 |     0.000 |
## -----|-----|-----|-----|-----|-----|-----|-----|
##      ST |      18 |       0 |       1 |       0 |      87 |       0 |     538 |
##      |     0.028 |     0.000 |     0.002 |     0.000 |     0.135 |     0.000 |     0.835 |
##      |     0.021 |     0.000 |     0.003 |     0.000 |     0.126 |     0.000 |     0.869 |
```

```
##           |      0.005 |      0.000 |      0.000 |      0.000 |      0.022 |      0.000 |      0.136 |
## -----|-----|-----|-----|-----|-----|-----|-----|
## Column Total |      876 |      713 |      300 |      406 |      691 |      353 |      619 |
##           |      0.221 |      0.180 |      0.076 |      0.103 |      0.175 |      0.089 |      0.156 |
## -----|-----|-----|-----|-----|-----|-----|-----|
##
##
```

```
accuracy(table(test_pred, test_y2))
```

```
## [1] 77.89288
```