Part 2 : Football Transfer Market Data Preprocessing

This notebook covers data cleaning, feature engineering, label encoding, scaling and general preprocessing for modelling.

Working in an iterative manner, we will carry out the same preprocessing steps three times. This is because we have create thre different merged datasets following EDA. ONe each for imputing using the mean, the median, and utilising a KNNImputer.

Importing Dependencies

In [172…

```
# Visualization Libraries
import matplotlib
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns
import mglearn

#Preprocessing Libraries
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.metrics import precision_score, recall_score, confusion_matrix, cla
from sklearn import preprocessing
from sklearn.preprocessing import MinMaxScaler, RobustScaler
from statsmodels.stats.anova import anova_lm
from statsmodels.formula.api import ols


# ML Libraries
from sklearn.ensemble import RandomForestClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.decomposition import PCA

# Evaluation Metrics
from yellowbrick.classifier import ClassificationReport
from sklearn import metrics

import warnings# Import this library to suppress the warnings
warnings.filterwarnings('ignore')   # The object 'warnings' is used to call the
```

Preprocessing: Mean Datasets

Loading data

In [4]:

```
# Reading in the data and assign it to 'df' variable/object
df = pd.read_csv("Merged_Data_4_Pre_Processing.csv")
```

Confirming load and viewing general information on dataset

In [5]:
```
df.shape
```

Out[5]:
```
(30130, 79)
```

In [6]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 30130 entries, 0 to 30129
Data columns (total 79 columns):
 #   Column                                Non-Null Count  Dtype
---  ------                                --------------  -----
 0   player_id                             30130 non-null  int64
 1   first_name                            28173 non-null  object
 2   last_name                             30130 non-null  object
 3   name                                  30130 non-null  object
 4   last_season                           30130 non-null  int64
 5   current_club_id                       30130 non-null  int64
 6   player_code                           30130 non-null  object
 7   country_of_birth                      27528 non-null  object
 8   city_of_birth                         28013 non-null  object
 9   country_of_citizenship                29587 non-null  object
 10  date_of_birth                         30130 non-null  object
 11  sub_position                          30130 non-null  object
 12  position                              30130 non-null  object
 13  foot                                  27844 non-null  object
 14  height_in_cm                          28099 non-null  float64
 15  market_value_in_eur                   30130 non-null  float64
 16  highest_market_value_in_eur           30130 non-null  float64
 17  contract_expiration_date              18799 non-null  object
 18  image_url                             30130 non-null  object
 19  url                                   30130 non-null  object
 20  current_club_domestic_competition_id  30130 non-null  object
 21  current_club_name                     30130 non-null  object
 22  age                                   30130 non-null  int64
 23  remaining_contract_days               18799 non-null  float64
 24  age_group                             30130 non-null  object
 25  games_total                           30130 non-null  int64
 26  goals_total                           30130 non-null  int64
 27  assists_total                         30130 non-null  int64
 28  minutes_played_total                  30130 non-null  int64
 29  goals_for_total                       30130 non-null  int64
 30  goals_against_total                   30130 non-null  int64
 31  clean_sheet_total                     30130 non-null  int64
 32  yellow_cards_total                    30130 non-null  int64
 33  red_cards_total                       30130 non-null  int64
 34  games_2019                            30130 non-null  float64
 35  goals_2019                            30130 non-null  float64
 36  assists_2019                          30130 non-null  float64
 37  minutes_played_2019                   30130 non-null  float64
 38  goals_for_2019                        30130 non-null  float64
 39  goals_against_2019                    30130 non-null  float64
 40  clean_sheet_2019                      30130 non-null  float64
 41  yellow_cards_2019                     30130 non-null  float64
 42  red_cards_2019                        30130 non-null  float64
 43  games_2020                            30130 non-null  float64
 44  goals_2020                            30130 non-null  float64
 45  assists_2020                          30130 non-null  float64
 46  minutes_played_2020                   30130 non-null  float64
 47  goals_for_2020                        30130 non-null  float64
 48  goals_against_2020                    30130 non-null  float64
 49  clean_sheet_2020                      30130 non-null  float64
 50  yellow_cards_2020                     30130 non-null  float64
 51  red_cards_2020                        30130 non-null  float64
 52  games_2021                            30130 non-null  float64
 53  goals_2021                            30130 non-null  float64
 54  assists_2021                          30130 non-null  float64
```

```
 55  minutes_played_2021                30130 non-null  float64
 56  goals_for_2021                     30130 non-null  float64
 57  goals_against_2021                 30130 non-null  float64
 58  clean_sheet_2021                   30130 non-null  float64
 59  yellow_cards_2021                  30130 non-null  float64
 60  red_cards_2021                     30130 non-null  float64
 61  games_2022                         30130 non-null  float64
 62  goals_2022                         30130 non-null  int64
 63  assists_2022                       30130 non-null  int64
 64  minutes_played_2022                30130 non-null  float64
 65  goals_for_2022                     30130 non-null  float64
 66  goals_against_2022                 30130 non-null  float64
 67  clean_sheet_2022                   30130 non-null  int64
 68  yellow_cards_2022                  30130 non-null  int64
 69  red_cards_2022                     30130 non-null  int64
 70  games_2023                         30130 non-null  float64
 71  goals_2023                         30130 non-null  float64
 72  assists_2023                       30130 non-null  float64
 73  minutes_played_2023                30130 non-null  float64
 74  goals_for_2023                     30130 non-null  float64
 75  goals_against_2023                 30130 non-null  float64
 76  clean_sheet_2023                   30130 non-null  float64
 77  yellow_cards_2023                  30130 non-null  float64
 78  red_cards_2023                     30130 non-null  float64
dtypes: float64(44), int64(18), object(17)
memory usage: 18.2+ MB
```

Generating a profile report for df

In [7]:
```
# from ydata_profiling import ProfileReport #importing profile report attribute

# ProfileReport(df)# generating a profile report of the dataset
```

```
Summarize dataset:   0%|          | 0/5 [00:00<?, ?it/s]
Generate report structure:   0%|          | 0/1 [00:00<?, ?it/s]
Render HTML:   0%|          | 0/1 [00:00<?, ?it/s]
```

Overview

Dataset statistics

Number of variables	79
Number of observations	30130
Missing cells	34198
Missing cells (%)	1.4%
Duplicate rows	0
Duplicate rows (%)	0.0%
Total size in memory	18.2 MiB
Average record size in memory	632.0 B

Variable types

Numeric	57
Text	10
DateTime	2
Categorical	10

Alerts

`player_id` is highly overall correlated with `last_season` and 2 other fields (last_season, age	**High correlation**

Out[7]:

Feature Engineering

Removing Unrequired Features

We discovered through EDA that the dataset contains players that have since retired. There entries are innaccurate and may introduce noise and bias. We will thus remove any player entries for players who have retired since 2022.

In [8]:
```
df2 = df[df['last_season'] >= 2022]
```

In [9]:
```
df2.shape
```

Out[9]: (10169, 79)

In [10]:
```
pd.set_option('display.max_row', None)
pd.set_option('display.max_columns', None)
```

In [11]:
```
df2.nunique()
```

Out[11]:

player_id	10169
first_name	3421
last_name	8445
name	10072
last_season	2
current_club_id	274
player_code	10067
country_of_birth	152
city_of_birth	4000
country_of_citizenship	144
date_of_birth	6562
sub_position	13
position	4
foot	3
height_in_cm	46
market_value_in_eur	134
highest_market_value_in_eur	159
contract_expiration_date	48
image_url	9066
url	10169
current_club_domestic_competition_id	14
current_club_name	274
age	28
remaining_contract_days	48
age_group	5
games_total	205
goals_total	91
assists_total	63
minutes_played_total	5227
goals_for_total	410
goals_against_total	256
clean_sheet_total	92
yellow_cards_total	55
red_cards_total	6
games_2019	57
goals_2019	35
assists_2019	24
minutes_played_2019	2203
goals_for_2019	128
goals_against_2019	83
clean_sheet_2019	27
yellow_cards_2019	21
red_cards_2019	3
games_2020	56
goals_2020	38
assists_2020	22
minutes_played_2020	2372
goals_for_2020	125
goals_against_2020	86
clean_sheet_2020	31
yellow_cards_2020	18
red_cards_2020	3
games_2021	55
goals_2021	35
assists_2021	23
minutes_played_2021	2610
goals_for_2021	130
goals_against_2021	84
clean_sheet_2021	27
yellow_cards_2021	19

```
red_cards_2021                      3
games_2022                         58
goals_2022                         33
assists_2022                       22
minutes_played_2022              2839
goals_for_2022                    126
goals_against_2022                 82
clean_sheet_2022                   29
yellow_cards_2022                  20
red_cards_2022                      4
games_2023                         21
goals_2023                         15
assists_2023                       10
minutes_played_2023              1118
goals_for_2023                     51
goals_against_2023                 36
clean_sheet_2023                   11
yellow_cards_2023                   8
red_cards_2023                      3
dtype: int64
```

In [12]:
```
df2.columns
```

Out[12]:
```
Index(['player_id', 'first_name', 'last_name', 'name', 'last_season',
       'current_club_id', 'player_code', 'country_of_birth', 'city_of_birth',
       'country_of_citizenship', 'date_of_birth', 'sub_position', 'position',
       'foot', 'height_in_cm', 'market_value_in_eur',
       'highest_market_value_in_eur', 'contract_expiration_date', 'image_url',
       'url', 'current_club_domestic_competition_id', 'current_club_name',
       'age', 'remaining_contract_days', 'age_group', 'games_total',
       'goals_total', 'assists_total', 'minutes_played_total',
       'goals_for_total', 'goals_against_total', 'clean_sheet_total',
       'yellow_cards_total', 'red_cards_total', 'games_2019', 'goals_2019',
       'assists_2019', 'minutes_played_2019', 'goals_for_2019',
       'goals_against_2019', 'clean_sheet_2019', 'yellow_cards_2019',
       'red_cards_2019', 'games_2020', 'goals_2020', 'assists_2020',
       'minutes_played_2020', 'goals_for_2020', 'goals_against_2020',
       'clean_sheet_2020', 'yellow_cards_2020', 'red_cards_2020', 'games_2021',
       'goals_2021', 'assists_2021', 'minutes_played_2021', 'goals_for_2021',
       'goals_against_2021', 'clean_sheet_2021', 'yellow_cards_2021',
       'red_cards_2021', 'games_2022', 'goals_2022', 'assists_2022',
       'minutes_played_2022', 'goals_for_2022', 'goals_against_2022',
       'clean_sheet_2022', 'yellow_cards_2022', 'red_cards_2022', 'games_2023',
       'goals_2023', 'assists_2023', 'minutes_played_2023', 'goals_for_2023',
       'goals_against_2023', 'clean_sheet_2023', 'yellow_cards_2023',
       'red_cards_2023'],
      dtype='object')
```

Removing features that will not aid in evaluating player market values such as unique identifiers, names and images, aswell as demographical features that may introduce bias. 'highest_market_value_in_eur' will also be removed as it derived from 'market_value_in_eur', our target label.

In [135…
```
df3 = df2.drop(['player_id', 'first_name', 'last_name', 'name', 'player_code', '
```

In [136…
```
df3.shape
```

Out[136…
```
(10169, 66)
```

In [137…

```
df3.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 10169 entries, 72 to 30129
Data columns (total 66 columns):
 #   Column                                Non-Null Count  Dtype
---  ------                                --------------  -----
 0   last_season                           10169 non-null  int64
 1   current_club_id                       10169 non-null  int64
 2   sub_position                          10169 non-null  object
 3   position                              10169 non-null  object
 4   foot                                  9574 non-null   object
 5   height_in_cm                          9518 non-null   float64
 6   market_value_in_eur                   10169 non-null  float64
 7   current_club_domestic_competition_id  10169 non-null  object
 8   current_club_name                     10169 non-null  object
 9   age                                   10169 non-null  int64
 10  remaining_contract_days               8945 non-null   float64
 11  age_group                             10169 non-null  object
 12  games_total                           10169 non-null  int64
 13  goals_total                           10169 non-null  int64
 14  assists_total                         10169 non-null  int64
 15  minutes_played_total                  10169 non-null  int64
 16  goals_for_total                       10169 non-null  int64
 17  goals_against_total                   10169 non-null  int64
 18  clean_sheet_total                     10169 non-null  int64
 19  yellow_cards_total                    10169 non-null  int64
 20  red_cards_total                       10169 non-null  int64
 21  games_2019                            10169 non-null  float64
 22  goals_2019                            10169 non-null  float64
 23  assists_2019                          10169 non-null  float64
 24  minutes_played_2019                   10169 non-null  float64
 25  goals_for_2019                        10169 non-null  float64
 26  goals_against_2019                    10169 non-null  float64
 27  clean_sheet_2019                      10169 non-null  float64
 28  yellow_cards_2019                     10169 non-null  float64
 29  red_cards_2019                        10169 non-null  float64
 30  games_2020                            10169 non-null  float64
 31  goals_2020                            10169 non-null  float64
 32  assists_2020                          10169 non-null  float64
 33  minutes_played_2020                   10169 non-null  float64
 34  goals_for_2020                        10169 non-null  float64
 35  goals_against_2020                    10169 non-null  float64
 36  clean_sheet_2020                      10169 non-null  float64
 37  yellow_cards_2020                     10169 non-null  float64
 38  red_cards_2020                        10169 non-null  float64
 39  games_2021                            10169 non-null  float64
 40  goals_2021                            10169 non-null  float64
 41  assists_2021                          10169 non-null  float64
 42  minutes_played_2021                   10169 non-null  float64
 43  goals_for_2021                        10169 non-null  float64
 44  goals_against_2021                    10169 non-null  float64
 45  clean_sheet_2021                      10169 non-null  float64
 46  yellow_cards_2021                     10169 non-null  float64
 47  red_cards_2021                        10169 non-null  float64
 48  games_2022                            10169 non-null  float64
 49  goals_2022                            10169 non-null  int64
 50  assists_2022                          10169 non-null  int64
 51  minutes_played_2022                   10169 non-null  float64
 52  goals_for_2022                        10169 non-null  float64
 53  goals_against_2022                    10169 non-null  float64
 54  clean_sheet_2022                      10169 non-null  int64
```

```
 55  yellow_cards_2022                     10169 non-null  int64
 56  red_cards_2022                        10169 non-null  int64
 57  games_2023                            10169 non-null  float64
 58  goals_2023                            10169 non-null  float64
 59  assists_2023                          10169 non-null  float64
 60  minutes_played_2023                   10169 non-null  float64
 61  goals_for_2023                        10169 non-null  float64
 62  goals_against_2023                    10169 non-null  float64
 63  clean_sheet_2023                      10169 non-null  float64
 64  yellow_cards_2023                     10169 non-null  float64
 65  red_cards_2023                        10169 non-null  float64
dtypes: float64(43), int64(17), object(6)
memory usage: 5.2+ MB
```

In [138…

```
df3.head(50)
```

Out[138...

	last_season	current_club_id	sub_position	position	foot	height_in_cm	market_
72	2022	418	Centre-Forward	Attack	right	185.0	
88	2023	678	Goalkeeper	Goalkeeper	right	188.0	
117	2023	367	Attacking Midfield	Midfield	right	180.0	
132	2022	1095	Goalkeeper	Goalkeeper	right	184.0	
135	2022	1519	Centre-Forward	Attack	left	185.0	
152	2023	2425	Defensive Midfield	Midfield	right	182.0	
161	2023	371	Goalkeeper	Goalkeeper	right	196.0	
163	2022	940	Goalkeeper	Goalkeeper	left	187.0	
175	2023	58	Centre-Back	Defender	left	189.0	
178	2023	511	Goalkeeper	Goalkeeper	NaN	190.0	
181	2023	336	Goalkeeper	Goalkeeper	left	190.0	
186	2023	380	Centre-Back	Defender	right	195.0	
187	2023	294	Right Winger	Attack	left	180.0	
190	2022	2239	Centre-Forward	Attack	right	187.0	
191	2022	703	Left Winger	Attack	left	175.0	
200	2023	903	Centre-Forward	Attack	right	180.0	
217	2022	931	Centre-Forward	Attack	right	189.0	
228	2023	105	Left-Back	Defender	left	172.0	
232	2023	2919	Centre-Back	Defender	right	180.0	
238	2023	347	Goalkeeper	Goalkeeper	right	184.0	
240	2022	533	Defensive Midfield	Midfield	right	180.0	

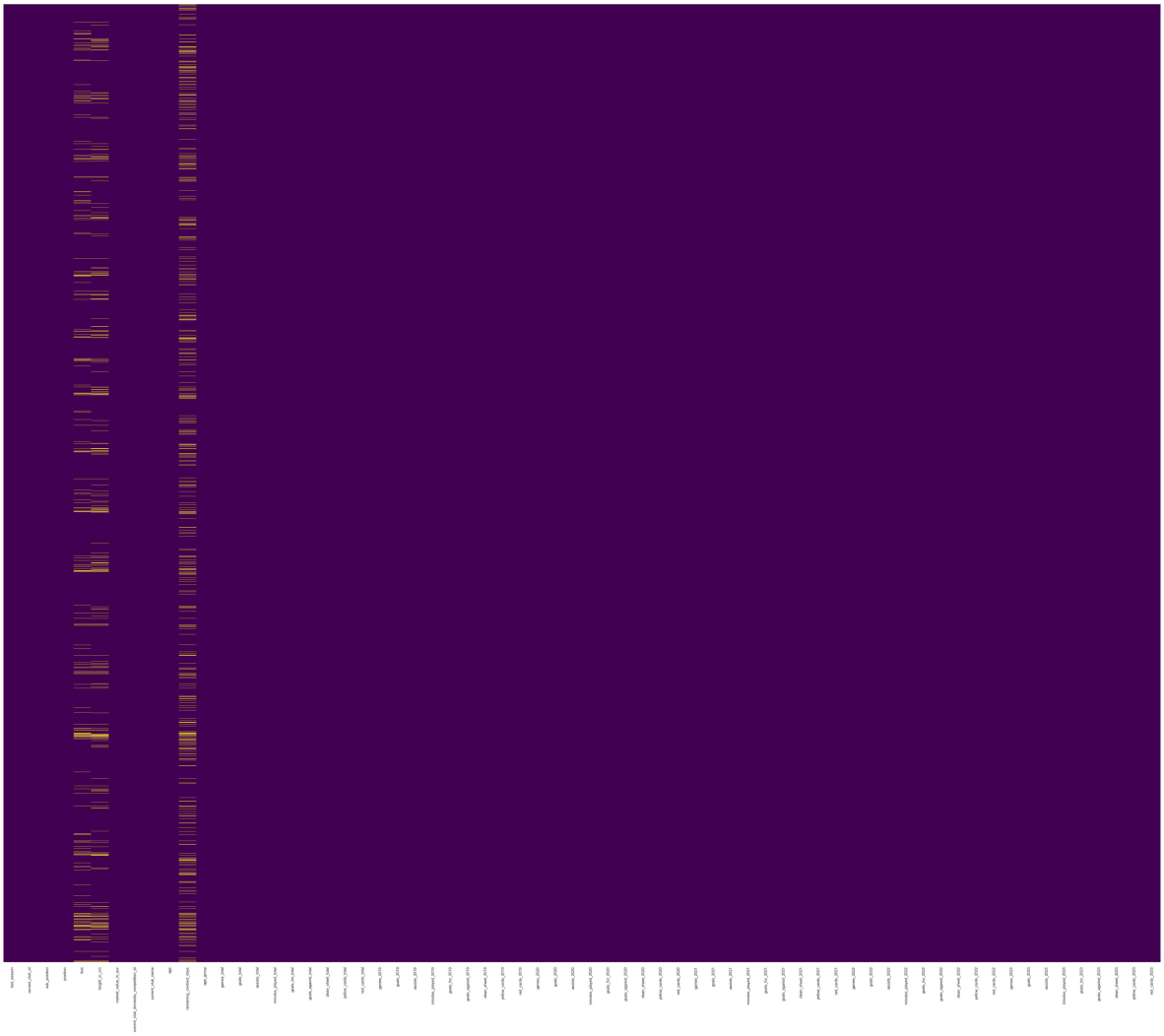
	last_season	current_club_id	sub_position	position	foot	height_in_cm	market_
246	2023	48332	Central Midfield	Midfield	right	182.0	
253	2023	418	Centre-Back	Defender	left	180.0	
255	2023	234	Centre-Back	Defender	right	183.0	
258	2023	232	Right Midfield	Midfield	right	177.0	
261	2023	3385	Centre-Back	Defender	right	190.0	
262	2022	667	Centre-Back	Defender	left	185.0	
277	2022	1025	Attacking Midfield	Midfield	right	182.0	
281	2023	12321	Centre-Back	Defender	right	192.0	
283	2023	398	Right Winger	Attack	both	167.0	
287	2022	2687	Centre-Back	Defender	right	186.0	
294	2023	1894	Attacking Midfield	Midfield	right	172.0	
295	2023	8024	Central Midfield	Midfield	left	183.0	
302	2022	678	Left-Back	Defender	both	188.0	
313	2023	273	Defensive Midfield	Midfield	left	194.0	
319	2022	667	Goalkeeper	Goalkeeper	right	185.0	
323	2023	3948	Goalkeeper	Goalkeeper	left	186.0	
326	2023	2578	Central Midfield	Midfield	right	179.0	
329	2023	1124	Right Winger	Attack	right	175.0	
332	2022	33	Centre-Back	Defender	right	189.0	
336	2023	873	Right-Back	Defender	right	175.0	
339	2023	1083	Attacking Midfield	Midfield	right	177.0	

	last_season	current_club_id	sub_position	position	foot	height_in_cm	market_
340	2023	418	Centre-Back	Defender	right	190.0	
344	2022	683	Attacking Midfield	Midfield	left	181.0	
349	2023	1245	Centre-Forward	Attack	right	184.0	
350	2023	968	Central Midfield	Midfield	left	175.0	
359	2023	58	Defensive Midfield	Midfield	right	178.0	
370	2023	60551	Right Midfield	Midfield	both	166.0	
372	2022	1096	Left Winger	Attack	right	181.0	
383	2022	3205	Central Midfield	Midfield	left	179.0	

Imputing Missing Values

In [139…
```
sns.heatmap(df3.isnull(),yticklabels=False,cbar=False,cmap='viridis')
```

Out[139…
```
<Axes: >
```



In [140…

```
df3.isnull().sum()
```

Out[140…

last_season	0
current_club_id	0
sub_position	0
position	0
foot	595
height_in_cm	651
market_value_in_eur	0
current_club_domestic_competition_id	0
current_club_name	0
age	0
remaining_contract_days	1224
age_group	0
games_total	0
goals_total	0
assists_total	0
minutes_played_total	0
goals_for_total	0
goals_against_total	0
clean_sheet_total	0
yellow_cards_total	0
red_cards_total	0
games_2019	0
goals_2019	0
assists_2019	0
minutes_played_2019	0
goals_for_2019	0
goals_against_2019	0
clean_sheet_2019	0
yellow_cards_2019	0
red_cards_2019	0
games_2020	0
goals_2020	0
assists_2020	0
minutes_played_2020	0
goals_for_2020	0
goals_against_2020	0
clean_sheet_2020	0
yellow_cards_2020	0
red_cards_2020	0
games_2021	0
goals_2021	0
assists_2021	0
minutes_played_2021	0
goals_for_2021	0
goals_against_2021	0
clean_sheet_2021	0
yellow_cards_2021	0
red_cards_2021	0
games_2022	0
goals_2022	0
assists_2022	0
minutes_played_2022	0
goals_for_2022	0
goals_against_2022	0
clean_sheet_2022	0
yellow_cards_2022	0
red_cards_2022	0
games_2023	0
goals_2023	0
assists_2023	0

```
minutes_played_2023                    0
goals_for_2023                         0
goals_against_2023                     0
clean_sheet_2023                       0
yellow_cards_2023                      0
red_cards_2023                         0
dtype: int64
```

In [141…
```
df3['height_in_cm'].describe()
```

Out[141…
```
count    9518.000000
mean      182.666527
std         6.928958
min       160.000000
25%       178.000000
50%       183.000000
75%       188.000000
max       206.000000
Name: height_in_cm, dtype: float64
```

In [142…
```
# Calculating the mean market values based on position and age category
mean_height_values = df3.groupby(['position', 'sub_position'])['height_in_cm'].m

# Displaying the mean values
print(mean_height_values)
```

	position	sub_position	height_in_cm
0	Attack	Centre-Forward	184.554187
1	Attack	Left Winger	176.814056
2	Attack	Right Winger	177.224924
3	Attack	Second Striker	178.676471
4	Defender	Centre-Back	187.966463
5	Defender	Left-Back	179.100575
6	Defender	Right-Back	179.516129
7	Goalkeeper	Goalkeeper	190.461938
8	Midfield	Attacking Midfield	177.996979
9	Midfield	Central Midfield	179.848057
10	Midfield	Defensive Midfield	182.069987
11	Midfield	Left Midfield	178.350649
12	Midfield	Right Midfield	177.253333

In [143…
```
# Writing a function of conditional statements for imputing the mean height valu
def impute_height(cols):
    height_in_cm = cols[0]
    position = cols[1]
    sub_position = cols[2]

    if pd.isnull(height_in_cm):

        if position == 'Attack':
            if sub_position == 'Centre-Forward':
                return 184.554187
            elif sub_position == 'Left Winger':
                return 176.814056
            elif sub_position == 'Right Winger':
                return 177.224924
            elif sub_position == 'Second Striker':
                return 178.676471
            else:
                return 182.666527
```

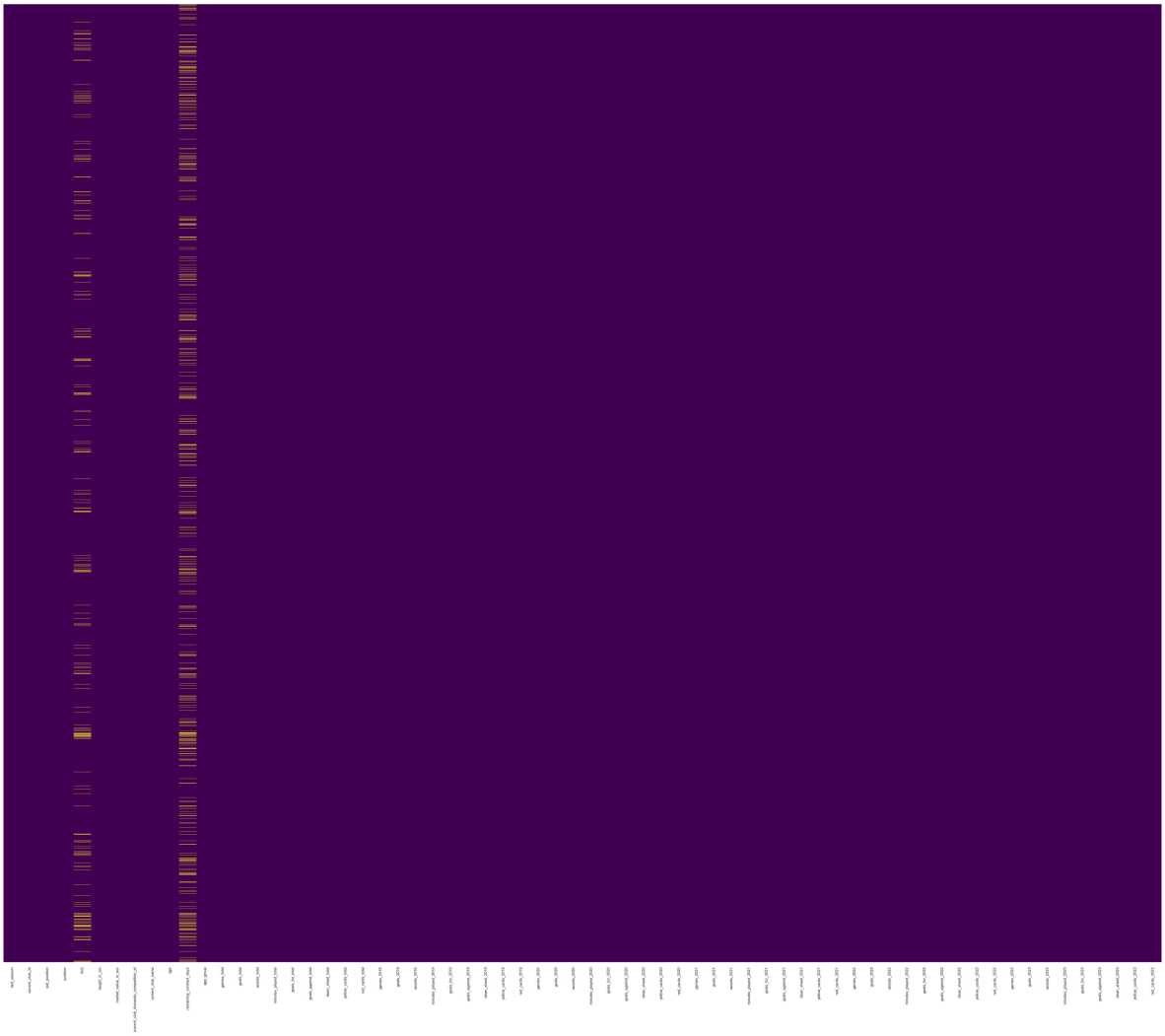
```
        elif position == 'Defender':
            if sub_position == 'Centre-Back':
                return 187.966463
            elif sub_position == 'Left-Back':
                return 179.100575
            elif sub_position == 'Right-Back':
                return 179.516129
            else:
                return 182.666527

        elif position == 'Goalkeeper':
            if sub_position == 'Goalkeeper':
                return 190.461938
            else:
                return 182.666527

        elif position == 'Midfield':
            if sub_position == 'Attacking Midfield':
                return 177.996979
            elif sub_position == 'Central Midfield':
                return 179.848057
            elif sub_position == 'Defensive Midfield':
                return 182.069987
            elif sub_position == 'Left Midfield':
                return 178.350649
            elif sub_position == 'Right Midfield':
                return 177.253333
            else:
                return 182.666527

        else:
            return 182.666527

    else:
        return height_in_cm
```

In [144…
```
df4 = df3.copy()
```

In [145…
```
# Applying the impute_height function to the dataframe
df4['height_in_cm'] = df4[['height_in_cm', 'position', 'sub_position']].apply(im
```

In [146…
```
sns.heatmap(df4.isnull(),yticklabels=False,cbar=False,cmap='viridis')
```

Out[146…
```
<Axes: >
```



In [147…
```
df3['foot'].describe()
```

Out[147…
```
count      9574
unique        3
top       right
freq       6737
Name: foot, dtype: object
```

In [148…
```
df4['foot'].unique()
```

Out[148…
```
array(['right', 'left', nan, 'both'], dtype=object)
```

In [149…
```
# Calculating the mode for foot values based on position and sub_position
mode_foot_values = df4.groupby(['position', 'sub_position'])['foot'].agg(lambda

# Displaying the mode values
print(mode_foot_values)
```

	position	sub_position	foot
0	Attack	Centre-Forward	right
1	Attack	Left Winger	right
2	Attack	Right Winger	right
3	Attack	Second Striker	right
4	Defender	Centre-Back	right
5	Defender	Left-Back	left
6	Defender	Right-Back	right
7	Goalkeeper	Goalkeeper	right
8	Midfield	Attacking Midfield	right
9	Midfield	Central Midfield	right
10	Midfield	Defensive Midfield	right
11	Midfield	Left Midfield	left
12	Midfield	Right Midfield	right

In [150…

```
# Writing a function of conditional statements for imputing the mode for foot ba
def impute_foot(cols):
    foot = cols[0]
    position = cols[1]
    sub_position = cols[2]

    if pd.isnull(foot):
        if position == 'Attack':
            return 'right'

        elif position == 'Defender':
            if sub_position == 'Left-Back':
                return 'left'
            else:
                return 'right'

        elif position == 'Goalkeeper':
            return 'right'

        elif position == 'Midfield':
            if sub_position == 'Left Midfield':
                return 'left'
            else:
                return 'right'

        else:
            return 'right'

    else:
        return foot
```

In [151…

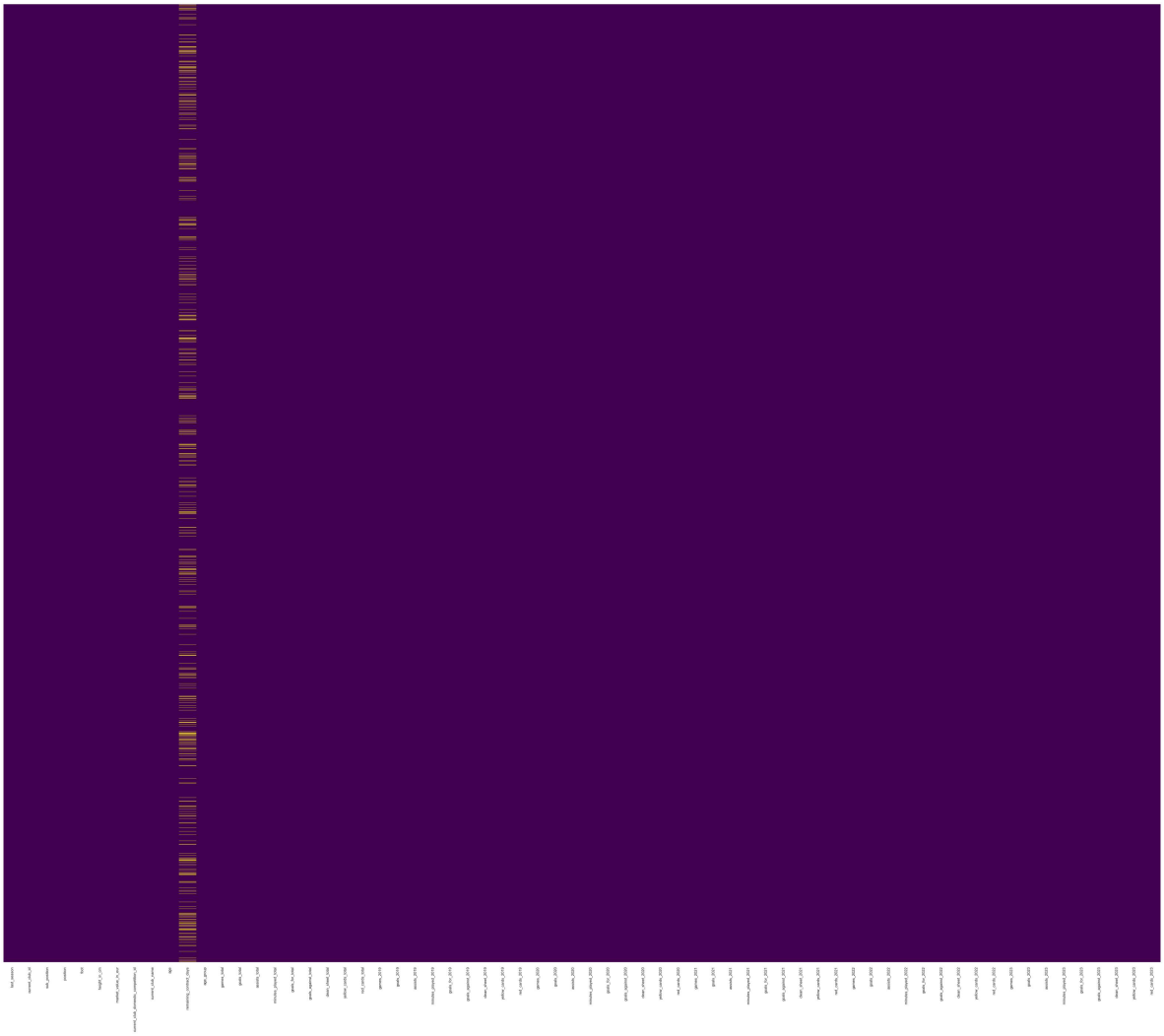
```
# Applying the impute_height function to the dataframe
df4['foot'] = df4[['foot', 'position', 'sub_position']].apply(impute_foot, axis=
```

In [152…

```
sns.heatmap(df4.isnull(),yticklabels=False,cbar=False,cmap='viridis')
```

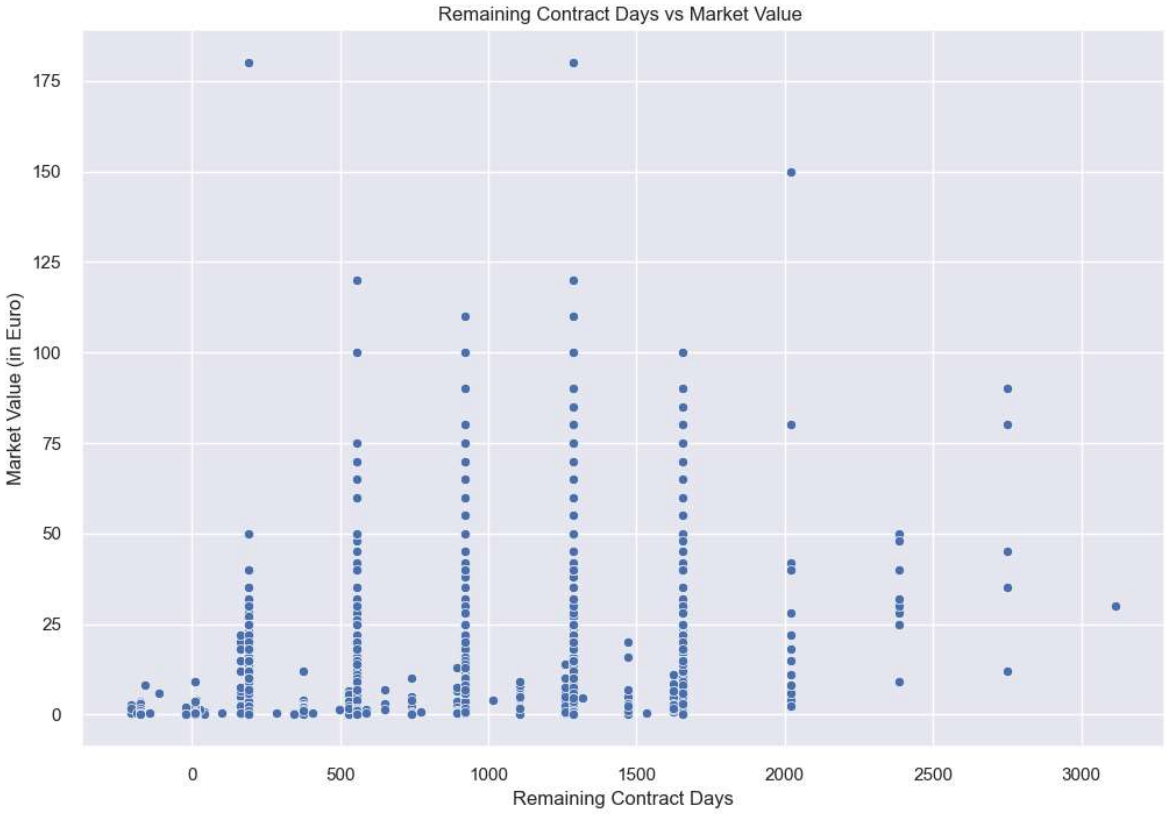
Out[152…

```
<Axes: >
```



In [153…

```
plt.figure(figsize=(12, 8))
sns.scatterplot(x='remaining_contract_days', y= df3['market_value_in_eur']/10000
plt.title('Remaining Contract Days vs Market Value ')
plt.xlabel('Remaining Contract Days')
plt.ylabel('Market Value (in Euro)')
plt.show()
```



In [154…
```
correlation = df4['remaining_contract_days'].corr(df3['market_value_in_eur'])
print(f"Correlation between remaining_contract_days and market_value_in_eur: {co
```

```
Correlation between remaining_contract_days and market_value_in_eur: 0.3408538150
5098444
```

In [155…
```
# Calculating the mean market values based on position and age category
mean_remaining_contract_days_values = df4.groupby(['market_value_in_eur'])['rema

# Displaying the mean values
print(mean_remaining_contract_days_values)
```

	market_value_in_eur	remaining_contract_days
0	10000.0	558.000000
1	25000.0	463.381818
2	50000.0	464.503846
3	75000.0	478.814815
4	100000.0	442.108359
5	125000.0	356.000000
6	150000.0	429.861423
7	175000.0	429.884615
8	176886.8	NaN
9	180000.0	528.000000
10	186000.0	NaN
11	200000.0	418.831731
12	225000.0	436.414634
13	250000.0	424.431034
14	275000.0	399.583333
15	300000.0	417.438228
16	325000.0	531.230769
17	346632.7	365.906250
18	350000.0	427.793269
19	375000.0	451.750000
20	400000.0	481.479911
21	425000.0	581.000000
22	443725.5	-173.000000
23	450000.0	493.759259
24	475000.0	309.666667
25	500000.0	521.254364
26	522411.7	558.000000
27	550000.0	444.179487
28	600000.0	476.108949
29	641563.3	NaN
30	650000.0	484.814815
31	700000.0	542.885593
32	715892.2	NaN
33	750000.0	586.320755
34	790010.7	NaN
35	800000.0	592.174089
36	850000.0	605.914286
37	900000.0	569.528000
38	950000.0	740.500000
39	1000000.0	594.446023
40	1093724.0	153.000000
41	1100000.0	485.000000
42	1200000.0	634.903743
43	1300000.0	481.609756
44	1400000.0	572.560000
45	1500000.0	583.622699
46	1579725.0	423.714286
47	1600000.0	472.117647
48	1700000.0	512.375000
49	1800000.0	571.346535
50	1836525.0	NaN
51	1900000.0	923.000000
52	2000000.0	624.398230
53	2100000.0	679.666667
54	2109582.0	NaN
55	2200000.0	663.346154
56	2209577.0	401.689655
57	2300000.0	740.571429
58	2400000.0	983.833333

59	2500000.0	669.604938
60	2519384.0	192.500000
61	2600000.0	375.500000
62	2641277.0	923.000000
63	2700000.0	591.181818
64	2715097.0	488.261538
65	2800000.0	714.041667
66	2989714.0	108.307692
67	3000000.0	673.625468
68	3100000.0	558.000000
69	3168564.0	192.800000
70	3200000.0	1014.250000
71	3300000.0	801.333333
72	3400000.0	679.666667
73	3500000.0	702.798387
74	3700000.0	862.166667
75	3761589.0	134.900000
76	3800000.0	723.909091
77	4000000.0	801.484211
78	4100000.0	558.000000
79	4200000.0	996.200000
80	4300000.0	375.500000
81	4500000.0	782.446429
82	4800000.0	649.250000
83	5000000.0	776.507692
84	5500000.0	801.461538
85	6000000.0	789.408451
86	6500000.0	863.809524
87	7000000.0	740.955056
88	7500000.0	908.714286
89	8000000.0	857.253846
90	8500000.0	1029.600000
91	9000000.0	956.378788
92	9500000.0	558.000000
93	10000000.0	858.383459
94	11000000.0	1126.812500
95	12000000.0	935.107843
96	13000000.0	1004.548387
97	14000000.0	1001.243243
98	15000000.0	1050.390000
99	16000000.0	916.153846
100	17000000.0	895.076923
101	18000000.0	995.723077
102	19000000.0	1105.500000
103	20000000.0	1079.066667
104	21000000.0	193.000000
105	22000000.0	1115.558824
106	23000000.0	193.000000
107	24000000.0	1507.600000
108	25000000.0	1048.852459
109	26000000.0	558.000000
110	27000000.0	923.000000
111	28000000.0	1251.900000
112	30000000.0	1129.076923
113	32000000.0	1091.692308
114	35000000.0	1194.976744
115	38000000.0	1235.857143
116	40000000.0	1186.441860
117	42000000.0	1242.625000
118	45000000.0	1236.071429

```
119          48000000.0              1532.000000
120          50000000.0              1027.476190
121          55000000.0              1421.363636
122          60000000.0              1314.571429
123          65000000.0              1197.166667
124          70000000.0              1085.555556
125          75000000.0              1151.250000
126          80000000.0              1653.625000
127          85000000.0              1410.000000
128          90000000.0              1516.625000
129         100000000.0              1105.666667
130         110000000.0              1105.500000
131         120000000.0               923.000000
132         150000000.0              2019.000000
133         180000000.0               740.500000
```

In [156…
```
df4['remaining_contract_days'].describe()
```

Out[156…
```
count    8945.000000
mean      609.395081
std       459.677277
min      -203.000000
25%       193.000000
50%       558.000000
75%       923.000000
max      3115.000000
Name: remaining_contract_days, dtype: float64
```

In [157…
```
mean_remaining_days = df4['remaining_contract_days'].mean().astype(int)
```

In [158…
```
df5 = df4.copy()
```

In [159…
```
df5['remaining_contract_days'].fillna(mean_remaining_days, inplace=True)
```

In [160…
```
df5.shape
```

Out[160…
```
(10169, 66)
```

In [161…
```
sns.heatmap(df5.isnull(),yticklabels=False,cbar=False,cmap='viridis')
```

Out[161…
```
<Axes: >
```

In [162…

```
df5.isnull().sum()
```

Out[162…

last_season	0
current_club_id	0
sub_position	0
position	0
foot	0
height_in_cm	0
market_value_in_eur	0
current_club_domestic_competition_id	0
current_club_name	0
age	0
remaining_contract_days	0
age_group	0
games_total	0
goals_total	0
assists_total	0
minutes_played_total	0
goals_for_total	0
goals_against_total	0
clean_sheet_total	0
yellow_cards_total	0
red_cards_total	0
games_2019	0
goals_2019	0
assists_2019	0
minutes_played_2019	0
goals_for_2019	0
goals_against_2019	0
clean_sheet_2019	0
yellow_cards_2019	0
red_cards_2019	0
games_2020	0
goals_2020	0
assists_2020	0
minutes_played_2020	0
goals_for_2020	0
goals_against_2020	0
clean_sheet_2020	0
yellow_cards_2020	0
red_cards_2020	0
games_2021	0
goals_2021	0
assists_2021	0
minutes_played_2021	0
goals_for_2021	0
goals_against_2021	0
clean_sheet_2021	0
yellow_cards_2021	0
red_cards_2021	0
games_2022	0
goals_2022	0
assists_2022	0
minutes_played_2022	0
goals_for_2022	0
goals_against_2022	0
clean_sheet_2022	0
yellow_cards_2022	0
red_cards_2022	0
games_2023	0
goals_2023	0
assists_2023	0

```
minutes_played_2023                  0
goals_for_2023                       0
goals_against_2023                   0
clean_sheet_2023                     0
yellow_cards_2023                    0
red_cards_2023                       0
dtype: int64
```

In [163…

```
df5.nunique()
```

Out[163…

last_season	2
current_club_id	274
sub_position	13
position	4
foot	3
height_in_cm	59
market_value_in_eur	134
current_club_domestic_competition_id	14
current_club_name	274
age	28
remaining_contract_days	49
age_group	5
games_total	205
goals_total	91
assists_total	63
minutes_played_total	5227
goals_for_total	410
goals_against_total	256
clean_sheet_total	92
yellow_cards_total	55
red_cards_total	6
games_2019	57
goals_2019	35
assists_2019	24
minutes_played_2019	2203
goals_for_2019	128
goals_against_2019	83
clean_sheet_2019	27
yellow_cards_2019	21
red_cards_2019	3
games_2020	56
goals_2020	38
assists_2020	22
minutes_played_2020	2372
goals_for_2020	125
goals_against_2020	86
clean_sheet_2020	31
yellow_cards_2020	18
red_cards_2020	3
games_2021	55
goals_2021	35
assists_2021	23
minutes_played_2021	2610
goals_for_2021	130
goals_against_2021	84
clean_sheet_2021	27
yellow_cards_2021	19
red_cards_2021	3
games_2022	58
goals_2022	33
assists_2022	22
minutes_played_2022	2839
goals_for_2022	126
goals_against_2022	82
clean_sheet_2022	29
yellow_cards_2022	20
red_cards_2022	4
games_2023	21
goals_2023	15
assists_2023	10

```
minutes_played_2023                1118
goals_for_2023                       51
goals_against_2023                   36
clean_sheet_2023                     11
yellow_cards_2023                     8
red_cards_2023                        3
dtype: int64
```

In [164…

```
df5.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 10169 entries, 72 to 30129
Data columns (total 66 columns):
 #   Column                                Non-Null Count  Dtype
---  ------                                --------------  -----
 0   last_season                           10169 non-null  int64
 1   current_club_id                       10169 non-null  int64
 2   sub_position                          10169 non-null  object
 3   position                              10169 non-null  object
 4   foot                                  10169 non-null  object
 5   height_in_cm                          10169 non-null  float64
 6   market_value_in_eur                   10169 non-null  float64
 7   current_club_domestic_competition_id  10169 non-null  object
 8   current_club_name                     10169 non-null  object
 9   age                                   10169 non-null  int64
 10  remaining_contract_days               10169 non-null  float64
 11  age_group                             10169 non-null  object
 12  games_total                           10169 non-null  int64
 13  goals_total                           10169 non-null  int64
 14  assists_total                         10169 non-null  int64
 15  minutes_played_total                  10169 non-null  int64
 16  goals_for_total                       10169 non-null  int64
 17  goals_against_total                   10169 non-null  int64
 18  clean_sheet_total                     10169 non-null  int64
 19  yellow_cards_total                    10169 non-null  int64
 20  red_cards_total                       10169 non-null  int64
 21  games_2019                            10169 non-null  float64
 22  goals_2019                            10169 non-null  float64
 23  assists_2019                          10169 non-null  float64
 24  minutes_played_2019                   10169 non-null  float64
 25  goals_for_2019                        10169 non-null  float64
 26  goals_against_2019                    10169 non-null  float64
 27  clean_sheet_2019                      10169 non-null  float64
 28  yellow_cards_2019                     10169 non-null  float64
 29  red_cards_2019                        10169 non-null  float64
 30  games_2020                            10169 non-null  float64
 31  goals_2020                            10169 non-null  float64
 32  assists_2020                          10169 non-null  float64
 33  minutes_played_2020                   10169 non-null  float64
 34  goals_for_2020                        10169 non-null  float64
 35  goals_against_2020                    10169 non-null  float64
 36  clean_sheet_2020                      10169 non-null  float64
 37  yellow_cards_2020                     10169 non-null  float64
 38  red_cards_2020                        10169 non-null  float64
 39  games_2021                            10169 non-null  float64
 40  goals_2021                            10169 non-null  float64
 41  assists_2021                          10169 non-null  float64
 42  minutes_played_2021                   10169 non-null  float64
 43  goals_for_2021                        10169 non-null  float64
 44  goals_against_2021                    10169 non-null  float64
 45  clean_sheet_2021                      10169 non-null  float64
 46  yellow_cards_2021                     10169 non-null  float64
 47  red_cards_2021                        10169 non-null  float64
 48  games_2022                            10169 non-null  float64
 49  goals_2022                            10169 non-null  int64
 50  assists_2022                          10169 non-null  int64
 51  minutes_played_2022                   10169 non-null  float64
 52  goals_for_2022                        10169 non-null  float64
 53  goals_against_2022                    10169 non-null  float64
 54  clean_sheet_2022                      10169 non-null  int64
```

```
 55  yellow_cards_2022                     10169 non-null  int64
 56  red_cards_2022                        10169 non-null  int64
 57  games_2023                            10169 non-null  float64
 58  goals_2023                            10169 non-null  float64
 59  assists_2023                          10169 non-null  float64
 60  minutes_played_2023                   10169 non-null  float64
 61  goals_for_2023                        10169 non-null  float64
 62  goals_against_2023                    10169 non-null  float64
 63  clean_sheet_2023                      10169 non-null  float64
 64  yellow_cards_2023                     10169 non-null  float64
 65  red_cards_2023                        10169 non-null  float64
dtypes: float64(43), int64(17), object(6)
memory usage: 5.2+ MB
```

Casting float datatypes to integer

In [ ]:
```
df5['market_value_in_eur'].unique
```

In [ ]:
```
df5['minutes_played_2019'].unique
```

The only numerical feature that need to be represented as float is a players height and player market value.

In [165…
```
# Simple function to iterate through the dataset and cast float type to int
def float_to_int(df):
    for column in df.columns:
        if df[column].dtype == 'float64' and column not in ['height_in_cm', 'mar
            df[column] = df[column].astype(int)
    return df
```

In [166…
```
# Applying the 'float_to_int' function on the dataset and storing the results to
df6 = float_to_int(df5)
```

In [167…
```
df6.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 10169 entries, 72 to 30129
Data columns (total 66 columns):
 #   Column                                Non-Null Count  Dtype
---  ------                                --------------  -----
 0   last_season                           10169 non-null  int64
 1   current_club_id                       10169 non-null  int64
 2   sub_position                          10169 non-null  object
 3   position                              10169 non-null  object
 4   foot                                  10169 non-null  object
 5   height_in_cm                          10169 non-null  float64
 6   market_value_in_eur                   10169 non-null  float64
 7   current_club_domestic_competition_id  10169 non-null  object
 8   current_club_name                     10169 non-null  object
 9   age                                   10169 non-null  int64
 10  remaining_contract_days               10169 non-null  int32
 11  age_group                             10169 non-null  object
 12  games_total                           10169 non-null  int64
 13  goals_total                           10169 non-null  int64
 14  assists_total                         10169 non-null  int64
 15  minutes_played_total                  10169 non-null  int64
 16  goals_for_total                       10169 non-null  int64
 17  goals_against_total                   10169 non-null  int64
 18  clean_sheet_total                     10169 non-null  int64
 19  yellow_cards_total                    10169 non-null  int64
 20  red_cards_total                       10169 non-null  int64
 21  games_2019                            10169 non-null  int32
 22  goals_2019                            10169 non-null  int32
 23  assists_2019                          10169 non-null  int32
 24  minutes_played_2019                   10169 non-null  int32
 25  goals_for_2019                        10169 non-null  int32
 26  goals_against_2019                    10169 non-null  int32
 27  clean_sheet_2019                      10169 non-null  int32
 28  yellow_cards_2019                     10169 non-null  int32
 29  red_cards_2019                        10169 non-null  int32
 30  games_2020                            10169 non-null  int32
 31  goals_2020                            10169 non-null  int32
 32  assists_2020                          10169 non-null  int32
 33  minutes_played_2020                   10169 non-null  int32
 34  goals_for_2020                        10169 non-null  int32
 35  goals_against_2020                    10169 non-null  int32
 36  clean_sheet_2020                      10169 non-null  int32
 37  yellow_cards_2020                     10169 non-null  int32
 38  red_cards_2020                        10169 non-null  int32
 39  games_2021                            10169 non-null  int32
 40  goals_2021                            10169 non-null  int32
 41  assists_2021                          10169 non-null  int32
 42  minutes_played_2021                   10169 non-null  int32
 43  goals_for_2021                        10169 non-null  int32
 44  goals_against_2021                    10169 non-null  int32
 45  clean_sheet_2021                      10169 non-null  int32
 46  yellow_cards_2021                     10169 non-null  int32
 47  red_cards_2021                        10169 non-null  int32
 48  games_2022                            10169 non-null  int32
 49  goals_2022                            10169 non-null  int64
 50  assists_2022                          10169 non-null  int64
 51  minutes_played_2022                   10169 non-null  int32
 52  goals_for_2022                        10169 non-null  int32
 53  goals_against_2022                    10169 non-null  int32
 54  clean_sheet_2022                      10169 non-null  int64
```

```
 55  yellow_cards_2022                     10169 non-null  int64
 56  red_cards_2022                        10169 non-null  int64
 57  games_2023                            10169 non-null  int32
 58  goals_2023                            10169 non-null  int32
 59  assists_2023                          10169 non-null  int32
 60  minutes_played_2023                   10169 non-null  int32
 61  goals_for_2023                        10169 non-null  int32
 62  goals_against_2023                    10169 non-null  int32
 63  clean_sheet_2023                      10169 non-null  int32
 64  yellow_cards_2023                     10169 non-null  int32
 65  red_cards_2023                        10169 non-null  int32
dtypes: float64(2), int32(41), int64(17), object(6)
memory usage: 3.6+ MB
```

Removing Duplicate Entries

In [168…
```
# Searching for duplicate rows and saving them to duplicateRows object
duplicateRows = df6[df6.duplicated()]
```

In [169…
```
# Viewing the duplicated entries
duplicateRows.head()
```

Out[169…

	last_season	current_club_id	sub_position	position	foot	height_in_cm	market_
19948	2022	399	Central Midfield	Midfield	right	179.848057	

In [170…
```
#Checking the shape of df6 before dropping duplicates
df6.shape
```

Out[170… `(10169, 66)`

In [171…
```
# Dropping duplicates and saving the new dataset as df6
df6 = df6.drop_duplicates()
```

In [172…
```
# Confirming the new shape after dropping the duplicated row
df6.shape
```

Out[172… `(10168, 66)`

More Feature Engineering

Feature Generation

Creating a feature for minutes per a goal for each of the last five seasons

In [173…
```
# Creating a new copy of the dataframe incase we need to refer back to df6
df7 = df6.copy()
```

In [174…
```
df7['mins_per_goal_2023'] = df7['minutes_played_2023']/df7['goals_2023']
```

In [175…
```
df7['mins_per_goal_2022'] = df7['minutes_played_2022']/df7['goals_2022']
```

In [176…
```
df7['mins_per_goal_2021'] = df7['minutes_played_2021']/df7['goals_2021']
```

In [177…
```
df7['mins_per_goal_2020'] = df7['minutes_played_2020']/df7['goals_2020']
```

In [178…
```
df7['mins_per_goal_2019'] = df7['minutes_played_2019']/df7['goals_2019']
```

Creating a feature for minutes per a goal for total goals and minutes over the last five seasons.

In [179…
```
df7['mins_per_goal_total'] = df7['minutes_played_total']/df7['goals_total']
```

Creating a feature for minutes per an assist for each of the last five seasons

In [180…
```
df7['mins_per_assist_2023'] = df7['minutes_played_2023']/df7['assists_2023']
```

In [181…
```
df7['mins_per_assist_2022'] = df7['minutes_played_2022']/df7['assists_2022']
```

In [182…
```
df7['mins_per_assist_2021'] = df7['minutes_played_2021']/df7['assists_2021']
```

In [183…
```
df7['mins_per_assist_2020'] = df7['minutes_played_2020']/df7['assists_2020']
```

In [184…
```
df7['mins_per_assist_2019'] = df7['minutes_played_2019']/df7['assists_2019']
```

Creating a feature for minutes per an assist for total assists and minutes over the last five seasons.

In [185…
```
df7['mins_per_assist_total'] = df7['minutes_played_total']/df7['assists_total']
```

In [186…
```
df7.isnull().sum()
```

Out[186…

last_season	0
current_club_id	0
sub_position	0
position	0
foot	0
height_in_cm	0
market_value_in_eur	0
current_club_domestic_competition_id	0
current_club_name	0
age	0
remaining_contract_days	0
age_group	0
games_total	0
goals_total	0
assists_total	0
minutes_played_total	0
goals_for_total	0
goals_against_total	0
clean_sheet_total	0
yellow_cards_total	0
red_cards_total	0
games_2019	0
goals_2019	0
assists_2019	0
minutes_played_2019	0
goals_for_2019	0
goals_against_2019	0
clean_sheet_2019	0
yellow_cards_2019	0
red_cards_2019	0
games_2020	0
goals_2020	0
assists_2020	0
minutes_played_2020	0
goals_for_2020	0
goals_against_2020	0
clean_sheet_2020	0
yellow_cards_2020	0
red_cards_2020	0
games_2021	0
goals_2021	0
assists_2021	0
minutes_played_2021	0
goals_for_2021	0
goals_against_2021	0
clean_sheet_2021	0
yellow_cards_2021	0
red_cards_2021	0
games_2022	0
goals_2022	0
assists_2022	0
minutes_played_2022	0
goals_for_2022	0
goals_against_2022	0
clean_sheet_2022	0
yellow_cards_2022	0
red_cards_2022	0
games_2023	0
goals_2023	0
assists_2023	0

```
minutes_played_2023                    0
goals_for_2023                         0
goals_against_2023                     0
clean_sheet_2023                       0
yellow_cards_2023                      0
red_cards_2023                         0
mins_per_goal_2023                  4555
mins_per_goal_2022                  3118
mins_per_goal_2021                  5158
mins_per_goal_2020                  5810
mins_per_goal_2019                  6434
mins_per_goal_total                 1335
mins_per_assist_2023                4555
mins_per_assist_2022                3118
mins_per_assist_2021                5158
mins_per_assist_2020                5810
mins_per_assist_2019                6434
mins_per_assist_total               1335
dtype: int64
```

In [187…

```
df7.head(50)
```

Out[187...

	last_season	current_club_id	sub_position	position	foot	height_in_cm	market_
72	2022	418	Centre-Forward	Attack	right	185.0	
88	2023	678	Goalkeeper	Goalkeeper	right	188.0	
117	2023	367	Attacking Midfield	Midfield	right	180.0	
132	2022	1095	Goalkeeper	Goalkeeper	right	184.0	
135	2022	1519	Centre-Forward	Attack	left	185.0	
152	2023	2425	Defensive Midfield	Midfield	right	182.0	
161	2023	371	Goalkeeper	Goalkeeper	right	196.0	
163	2022	940	Goalkeeper	Goalkeeper	left	187.0	
175	2023	58	Centre-Back	Defender	left	189.0	
178	2023	511	Goalkeeper	Goalkeeper	right	190.0	
181	2023	336	Goalkeeper	Goalkeeper	left	190.0	
186	2023	380	Centre-Back	Defender	right	195.0	
187	2023	294	Right Winger	Attack	left	180.0	
190	2022	2239	Centre-Forward	Attack	right	187.0	
191	2022	703	Left Winger	Attack	left	175.0	
200	2023	903	Centre-Forward	Attack	right	180.0	
217	2022	931	Centre-Forward	Attack	right	189.0	
228	2023	105	Left-Back	Defender	left	172.0	
232	2023	2919	Centre-Back	Defender	right	180.0	
238	2023	347	Goalkeeper	Goalkeeper	right	184.0	
240	2022	533	Defensive Midfield	Midfield	right	180.0	

	last_season	current_club_id	sub_position	position	foot	height_in_cm	market_
246	2023	48332	Central Midfield	Midfield	right	182.0	
253	2023	418	Centre-Back	Defender	left	180.0	
255	2023	234	Centre-Back	Defender	right	183.0	
258	2023	232	Right Midfield	Midfield	right	177.0	
261	2023	3385	Centre-Back	Defender	right	190.0	
262	2022	667	Centre-Back	Defender	left	185.0	
277	2022	1025	Attacking Midfield	Midfield	right	182.0	
281	2023	12321	Centre-Back	Defender	right	192.0	
283	2023	398	Right Winger	Attack	both	167.0	
287	2022	2687	Centre-Back	Defender	right	186.0	
294	2023	1894	Attacking Midfield	Midfield	right	172.0	
295	2023	8024	Central Midfield	Midfield	left	183.0	
302	2022	678	Left-Back	Defender	both	188.0	
313	2023	273	Defensive Midfield	Midfield	left	194.0	
319	2022	667	Goalkeeper	Goalkeeper	right	185.0	
323	2023	3948	Goalkeeper	Goalkeeper	left	186.0	
326	2023	2578	Central Midfield	Midfield	right	179.0	
329	2023	1124	Right Winger	Attack	right	175.0	
332	2022	33	Centre-Back	Defender	right	189.0	
336	2023	873	Right-Back	Defender	right	175.0	
339	2023	1083	Attacking Midfield	Midfield	right	177.0	

	last_season	current_club_id	sub_position	position	foot	height_in_cm	market_
340	2023	418	Centre-Back	Defender	right	190.0	
344	2022	683	Attacking Midfield	Midfield	left	181.0	
349	2023	1245	Centre-Forward	Attack	right	184.0	
350	2023	968	Central Midfield	Midfield	left	175.0	
359	2023	58	Defensive Midfield	Midfield	right	178.0	
370	2023	60551	Right Midfield	Midfield	both	166.0	
372	2022	1096	Left Winger	Attack	right	181.0	
383	2022	3205	Central Midfield	Midfield	left	179.0	

The new features contain Nan and inf values as some plays have not scored or assisted or played any minutes. 0/0 = Nan, 0/number = inf. Our ML models cannot handle these values. We will impute them with a large value for infinity.

In [188…

```
# Setting a large number in scientific notation for infinity
#INF = 1e400

nan_inf_features_list = ['mins_per_goal_2023', 'mins_per_goal_2022', 'mins_per_g

# Replacing the NaN and inf values with 1e400
for feature in nan_inf_features_list:
    df7[feature].replace([np.nan, np.inf], 1e400, inplace=True)
```

In [189…

```
df7.isnull().sum()
```

Out[189…

last_season	0
current_club_id	0
sub_position	0
position	0
foot	0
height_in_cm	0
market_value_in_eur	0
current_club_domestic_competition_id	0
current_club_name	0
age	0
remaining_contract_days	0
age_group	0
games_total	0
goals_total	0
assists_total	0
minutes_played_total	0
goals_for_total	0
goals_against_total	0
clean_sheet_total	0
yellow_cards_total	0
red_cards_total	0
games_2019	0
goals_2019	0
assists_2019	0
minutes_played_2019	0
goals_for_2019	0
goals_against_2019	0
clean_sheet_2019	0
yellow_cards_2019	0
red_cards_2019	0
games_2020	0
goals_2020	0
assists_2020	0
minutes_played_2020	0
goals_for_2020	0
goals_against_2020	0
clean_sheet_2020	0
yellow_cards_2020	0
red_cards_2020	0
games_2021	0
goals_2021	0
assists_2021	0
minutes_played_2021	0
goals_for_2021	0
goals_against_2021	0
clean_sheet_2021	0
yellow_cards_2021	0
red_cards_2021	0
games_2022	0
goals_2022	0
assists_2022	0
minutes_played_2022	0
goals_for_2022	0
goals_against_2022	0
clean_sheet_2022	0
yellow_cards_2022	0
red_cards_2022	0
games_2023	0
goals_2023	0
assists_2023	0

```
minutes_played_2023                   0
goals_for_2023                        0
goals_against_2023                    0
clean_sheet_2023                      0
yellow_cards_2023                     0
red_cards_2023                        0
mins_per_goal_2023                    0
mins_per_goal_2022                    0
mins_per_goal_2021                    0
mins_per_goal_2020                    0
mins_per_goal_2019                    0
mins_per_goal_total                   0
mins_per_assist_2023                  0
mins_per_assist_2022                  0
mins_per_assist_2021                  0
mins_per_assist_2020                  0
mins_per_assist_2019                  0
mins_per_assist_total                 0
dtype: int64
```

Label Encoding

One-hot Label Encoding (dummies)

One-hot Label Encoding will be used instead of factorising variables or standard label encoding as there is no order or rank between the categorical variables. It will create a new binary feature for each category and assigns a value of 1 or 0 depending on whether that player belongs to that category.

In [223…

```
df7.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 10168 entries, 72 to 30129
Data columns (total 78 columns):
 #   Column                                Non-Null Count  Dtype
---  ------                                --------------  -----
 0   last_season                           10168 non-null  int64
 1   current_club_id                       10168 non-null  int64
 2   sub_position                          10168 non-null  object
 3   position                              10168 non-null  object
 4   foot                                  10168 non-null  object
 5   height_in_cm                          10168 non-null  float64
 6   market_value_in_eur                   10168 non-null  float64
 7   current_club_domestic_competition_id  10168 non-null  object
 8   current_club_name                     10168 non-null  object
 9   age                                   10168 non-null  int64
 10  remaining_contract_days               10168 non-null  int32
 11  age_group                             10168 non-null  object
 12  games_total                           10168 non-null  int64
 13  goals_total                           10168 non-null  int64
 14  assists_total                         10168 non-null  int64
 15  minutes_played_total                  10168 non-null  int64
 16  goals_for_total                       10168 non-null  int64
 17  goals_against_total                   10168 non-null  int64
 18  clean_sheet_total                     10168 non-null  int64
 19  yellow_cards_total                    10168 non-null  int64
 20  red_cards_total                       10168 non-null  int64
 21  games_2019                            10168 non-null  int32
 22  goals_2019                            10168 non-null  int32
 23  assists_2019                          10168 non-null  int32
 24  minutes_played_2019                   10168 non-null  int32
 25  goals_for_2019                        10168 non-null  int32
 26  goals_against_2019                    10168 non-null  int32
 27  clean_sheet_2019                      10168 non-null  int32
 28  yellow_cards_2019                     10168 non-null  int32
 29  red_cards_2019                        10168 non-null  int32
 30  games_2020                            10168 non-null  int32
 31  goals_2020                            10168 non-null  int32
 32  assists_2020                          10168 non-null  int32
 33  minutes_played_2020                   10168 non-null  int32
 34  goals_for_2020                        10168 non-null  int32
 35  goals_against_2020                    10168 non-null  int32
 36  clean_sheet_2020                      10168 non-null  int32
 37  yellow_cards_2020                     10168 non-null  int32
 38  red_cards_2020                        10168 non-null  int32
 39  games_2021                            10168 non-null  int32
 40  goals_2021                            10168 non-null  int32
 41  assists_2021                          10168 non-null  int32
 42  minutes_played_2021                   10168 non-null  int32
 43  goals_for_2021                        10168 non-null  int32
 44  goals_against_2021                    10168 non-null  int32
 45  clean_sheet_2021                      10168 non-null  int32
 46  yellow_cards_2021                     10168 non-null  int32
 47  red_cards_2021                        10168 non-null  int32
 48  games_2022                            10168 non-null  int32
 49  goals_2022                            10168 non-null  int64
 50  assists_2022                          10168 non-null  int64
 51  minutes_played_2022                   10168 non-null  int32
 52  goals_for_2022                        10168 non-null  int32
 53  goals_against_2022                    10168 non-null  int32
 54  clean_sheet_2022                      10168 non-null  int64
```

```
 55  yellow_cards_2022                     10168 non-null  int64
 56  red_cards_2022                        10168 non-null  int64
 57  games_2023                            10168 non-null  int32
 58  goals_2023                            10168 non-null  int32
 59  assists_2023                          10168 non-null  int32
 60  minutes_played_2023                   10168 non-null  int32
 61  goals_for_2023                        10168 non-null  int32
 62  goals_against_2023                    10168 non-null  int32
 63  clean_sheet_2023                      10168 non-null  int32
 64  yellow_cards_2023                     10168 non-null  int32
 65  red_cards_2023                        10168 non-null  int32
 66  mins_per_goal_2023                    10168 non-null  float64
 67  mins_per_goal_2022                    10168 non-null  float64
 68  mins_per_goal_2021                    10168 non-null  float64
 69  mins_per_goal_2020                    10168 non-null  float64
 70  mins_per_goal_2019                    10168 non-null  float64
 71  mins_per_goal_total                   10168 non-null  float64
 72  mins_per_assist_2023                  10168 non-null  float64
 73  mins_per_assist_2022                  10168 non-null  float64
 74  mins_per_assist_2021                  10168 non-null  float64
 75  mins_per_assist_2020                  10168 non-null  float64
 76  mins_per_assist_2019                  10168 non-null  float64
 77  mins_per_assist_total                 10168 non-null  float64
dtypes: float64(14), int32(41), int64(17), object(6)
memory usage: 4.5+ MB
```

Initially a dataframe of all categorical variables was create but applying one-hot label encoding to it resulted in boolen type features. i thus decided to try splitting them into essential and non-essential categoricals.

In [234…
```
df7['last_season'] = df7['last_season'].astype(str)
```

In [235…
```
# Isolating the categorical features for encoding
dummies_df_essential_cats = df7[['last_season','sub_position', 'position', 'foot
dummies_df_non_essential_cats = df7[['current_club_domestic_competition_id', 'cu
```

In [236…
```
dummies_df_essential_cats.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 10168 entries, 72 to 30129
Data columns (total 5 columns):
 #   Column         Non-Null Count  Dtype 
---  ------         --------------  ----- 
 0   last_season    10168 non-null  object
 1   sub_position   10168 non-null  object
 2   position       10168 non-null  object
 3   foot           10168 non-null  object
 4   age_group      10168 non-null  object
dtypes: object(5)
memory usage: 476.6+ KB
```

In [237…
```
dummies_df_essential_cats = pd.get_dummies(dummies_df_essential_cats, dtype=int)
```

In [238…
```
dummies_df_essential_cats.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 10168 entries, 72 to 30129
Data columns (total 27 columns):
 #   Column                            Non-Null Count  Dtype
---  ------                            --------------  -----
 0   last_season_2022                  10168 non-null  int32
 1   last_season_2023                  10168 non-null  int32
 2   sub_position_Attacking Midfield   10168 non-null  int32
 3   sub_position_Central Midfield     10168 non-null  int32
 4   sub_position_Centre-Back          10168 non-null  int32
 5   sub_position_Centre-Forward       10168 non-null  int32
 6   sub_position_Defensive Midfield   10168 non-null  int32
 7   sub_position_Goalkeeper           10168 non-null  int32
 8   sub_position_Left Midfield        10168 non-null  int32
 9   sub_position_Left Winger          10168 non-null  int32
 10  sub_position_Left-Back            10168 non-null  int32
 11  sub_position_Right Midfield       10168 non-null  int32
 12  sub_position_Right Winger         10168 non-null  int32
 13  sub_position_Right-Back           10168 non-null  int32
 14  sub_position_Second Striker       10168 non-null  int32
 15  position_Attack                   10168 non-null  int32
 16  position_Defender                 10168 non-null  int32
 17  position_Goalkeeper               10168 non-null  int32
 18  position_Midfield                 10168 non-null  int32
 19  foot_both                         10168 non-null  int32
 20  foot_left                         10168 non-null  int32
 21  foot_right                        10168 non-null  int32
 22  age_group_Ages 22 - 26            10168 non-null  int32
 23  age_group_Ages 27 - 32            10168 non-null  int32
 24  age_group_Ages 33 - 38            10168 non-null  int32
 25  age_group_Ages 39 - 44            10168 non-null  int32
 26  age_group_Ages Under 22           10168 non-null  int32
dtypes: int32(27)
memory usage: 1.1 MB
```

In [239…
```
dummies_df_essential_cats.head()
```

Out[239…

	last_season_2022	last_season_2023	sub_position_Attacking Midfield	sub_position_Central Midfield	su
72	1	0	0	0	
88	0	1	0	0	
117	0	1	1	0	
132	1	0	0	0	
135	1	0	0	0	

In [240…
```
dummies_df_essential_cats.shape
```

Out[240…
```
(10168, 27)
```

In [241…
```
dummies_df_non_essential_cats = pd.get_dummies(dummies_df_non_essential_cats, dt
```

In [242…
```
dummies_df_non_essential_cats.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 10168 entries, 72 to 30129
Columns: 288 entries, current_club_domestic_competition_id_BE1 to current_club_na
me_Ümraniyespor
dtypes: int32(288)
memory usage: 11.2 MB
```

In [243…
```
dummies_df_non_essential_cats.shape
```

Out[243…
```
(10168, 288)
```

In [244…
```
all_dummies  = pd.concat([dummies_df_essential_cats, dummies_df_non_essential_ca
```

In [245…
```
all_dummies.shape
```

Out[245…
```
(10168, 315)
```

Combining the dummies generated datasets to the original numerical features

Multiple datasets will be created and tested in our ML models.

A combined dataset of all categorical features following dummies...shape(10168, 386).

A dataset of numerical features and only 'foot', 'position', 'sub_position' and 'age_group' catergories following one-hot label encoding...shape(10168, 98)

And another following feature selection...

In [246…
```
numerical_features_df = df7.drop(['last_season','sub_position', 'position', 'foo
```

In [247…
```
df8_dummies_essential = pd.concat([numerical_features_df, dummies_df_essential_c
```

In [248…
```
df8_dummies_essential.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 10168 entries, 72 to 30129
Data columns (total 98 columns):
 #   Column                          Non-Null Count  Dtype
---  ------                          --------------  -----
 0   current_club_id                 10168 non-null  int64
 1   height_in_cm                    10168 non-null  float64
 2   market_value_in_eur             10168 non-null  float64
 3   age                             10168 non-null  int64
 4   remaining_contract_days         10168 non-null  int32
 5   games_total                     10168 non-null  int64
 6   goals_total                     10168 non-null  int64
 7   assists_total                   10168 non-null  int64
 8   minutes_played_total            10168 non-null  int64
 9   goals_for_total                 10168 non-null  int64
 10  goals_against_total             10168 non-null  int64
 11  clean_sheet_total               10168 non-null  int64
 12  yellow_cards_total              10168 non-null  int64
 13  red_cards_total                 10168 non-null  int64
 14  games_2019                      10168 non-null  int32
 15  goals_2019                      10168 non-null  int32
 16  assists_2019                    10168 non-null  int32
 17  minutes_played_2019             10168 non-null  int32
 18  goals_for_2019                  10168 non-null  int32
 19  goals_against_2019              10168 non-null  int32
 20  clean_sheet_2019                10168 non-null  int32
 21  yellow_cards_2019               10168 non-null  int32
 22  red_cards_2019                  10168 non-null  int32
 23  games_2020                      10168 non-null  int32
 24  goals_2020                      10168 non-null  int32
 25  assists_2020                    10168 non-null  int32
 26  minutes_played_2020             10168 non-null  int32
 27  goals_for_2020                  10168 non-null  int32
 28  goals_against_2020              10168 non-null  int32
 29  clean_sheet_2020                10168 non-null  int32
 30  yellow_cards_2020               10168 non-null  int32
 31  red_cards_2020                  10168 non-null  int32
 32  games_2021                      10168 non-null  int32
 33  goals_2021                      10168 non-null  int32
 34  assists_2021                    10168 non-null  int32
 35  minutes_played_2021             10168 non-null  int32
 36  goals_for_2021                  10168 non-null  int32
 37  goals_against_2021              10168 non-null  int32
 38  clean_sheet_2021                10168 non-null  int32
 39  yellow_cards_2021               10168 non-null  int32
 40  red_cards_2021                  10168 non-null  int32
 41  games_2022                      10168 non-null  int32
 42  goals_2022                      10168 non-null  int64
 43  assists_2022                    10168 non-null  int64
 44  minutes_played_2022             10168 non-null  int32
 45  goals_for_2022                  10168 non-null  int32
 46  goals_against_2022              10168 non-null  int32
 47  clean_sheet_2022                10168 non-null  int64
 48  yellow_cards_2022               10168 non-null  int64
 49  red_cards_2022                  10168 non-null  int64
 50  games_2023                      10168 non-null  int32
 51  goals_2023                      10168 non-null  int32
 52  assists_2023                    10168 non-null  int32
 53  minutes_played_2023             10168 non-null  int32
 54  goals_for_2023                  10168 non-null  int32
```

```
 55  goals_against_2023               10168 non-null  int32
 56  clean_sheet_2023                 10168 non-null  int32
 57  yellow_cards_2023                10168 non-null  int32
 58  red_cards_2023                   10168 non-null  int32
 59  mins_per_goal_2023               10168 non-null  float64
 60  mins_per_goal_2022               10168 non-null  float64
 61  mins_per_goal_2021               10168 non-null  float64
 62  mins_per_goal_2020               10168 non-null  float64
 63  mins_per_goal_2019               10168 non-null  float64
 64  mins_per_goal_total              10168 non-null  float64
 65  mins_per_assist_2023             10168 non-null  float64
 66  mins_per_assist_2022             10168 non-null  float64
 67  mins_per_assist_2021             10168 non-null  float64
 68  mins_per_assist_2020             10168 non-null  float64
 69  mins_per_assist_2019             10168 non-null  float64
 70  mins_per_assist_total            10168 non-null  float64
 71  last_season_2022                 10168 non-null  int32
 72  last_season_2023                 10168 non-null  int32
 73  sub_position_Attacking Midfield  10168 non-null  int32
 74  sub_position_Central Midfield    10168 non-null  int32
 75  sub_position_Centre-Back         10168 non-null  int32
 76  sub_position_Centre-Forward      10168 non-null  int32
 77  sub_position_Defensive Midfield  10168 non-null  int32
 78  sub_position_Goalkeeper          10168 non-null  int32
 79  sub_position_Left Midfield       10168 non-null  int32
 80  sub_position_Left Winger         10168 non-null  int32
 81  sub_position_Left-Back           10168 non-null  int32
 82  sub_position_Right Midfield      10168 non-null  int32
 83  sub_position_Right Winger        10168 non-null  int32
 84  sub_position_Right-Back          10168 non-null  int32
 85  sub_position_Second Striker      10168 non-null  int32
 86  position_Attack                  10168 non-null  int32
 87  position_Defender                10168 non-null  int32
 88  position_Goalkeeper              10168 non-null  int32
 89  position_Midfield                10168 non-null  int32
 90  foot_both                        10168 non-null  int32
 91  foot_left                        10168 non-null  int32
 92  foot_right                       10168 non-null  int32
 93  age_group_Ages 22 - 26           10168 non-null  int32
 94  age_group_Ages 27 - 32           10168 non-null  int32
 95  age_group_Ages 33 - 38           10168 non-null  int32
 96  age_group_Ages 39 - 44           10168 non-null  int32
 97  age_group_Ages Under 22          10168 non-null  int32
dtypes: float64(14), int32(68), int64(16)
memory usage: 5.0 MB
```

In [249…
```
df8_dummies_all = pd.concat([numerical_features_df, all_dummies], axis=1)
```

In [250…
```
df8_dummies_all.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 10168 entries, 72 to 30129
Columns: 386 entries, current_club_id to current_club_name_Ümraniyespor
dtypes: float64(14), int32(356), int64(16)
memory usage: 16.2 MB
```

Correlation Between Features

Pairplot between features and target variable

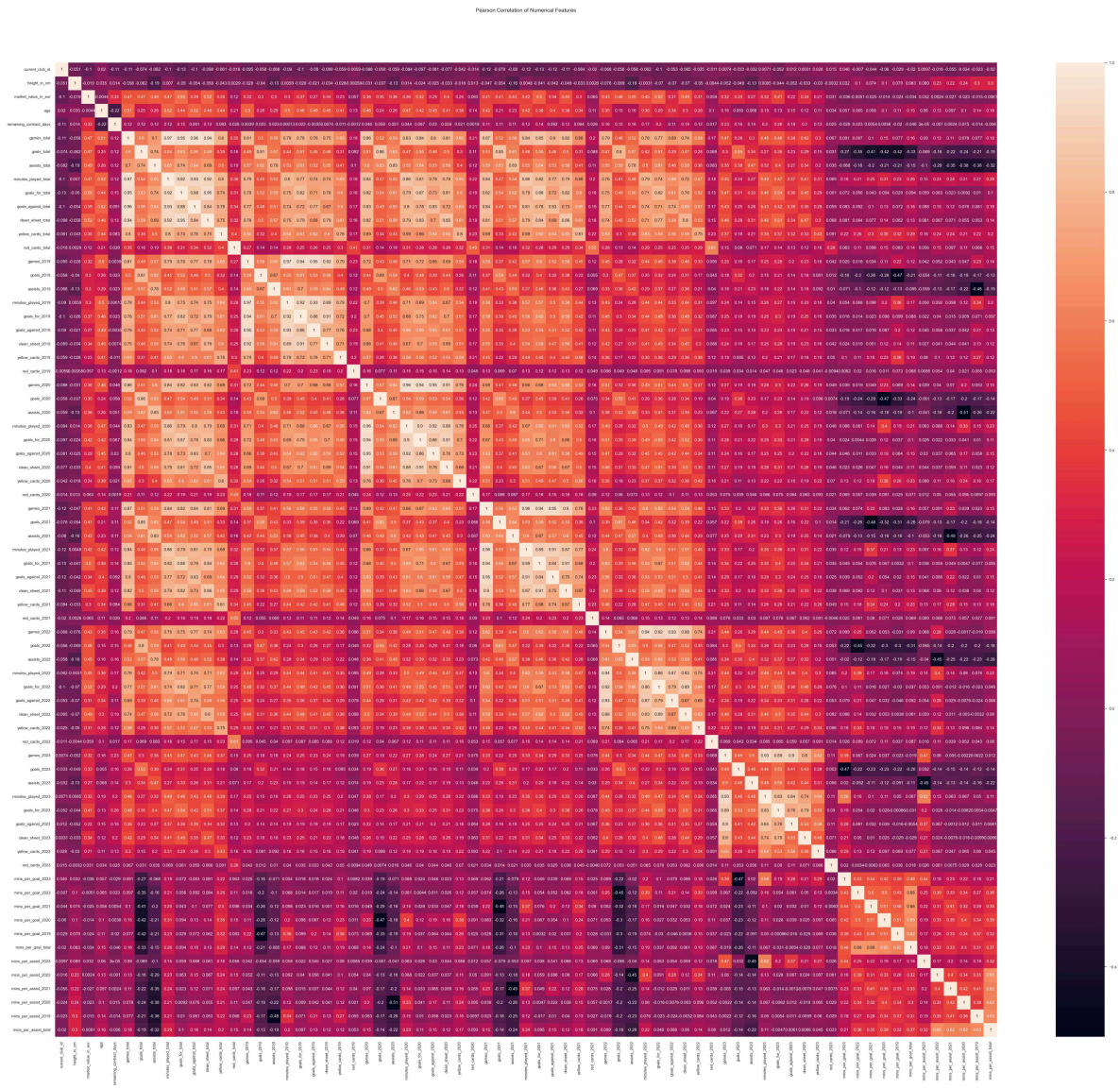
In [207…

```
# sns.pairplot(df7, hue='market_value_in_eur')
# plt.show()
```

Pearsons Correlation Matrix of Numerical Features

In [251…

```
# Plot a heatmap of the correlation matrix of the numerical columns
sns.set(rc={"figure.figsize":(60, 50)})
sns.heatmap(numerical_features_df.corr(), annot = True)
plt.title('Pearson Correlation of Numerical Features', y=1.05, size=15)
cor = numerical_features_df.corr()
plt.show()
```



Correlation Matrix: The correlation coefficient has values between -1 to 1. A value closer to 0 implies weaker correlation (exact 0 implying no correlation) A value closer to 1 implies stronger positive correlation A value closer to -1 implies stronger negative correlation.

There is no specific threshold for the correlation coefficient that dictates a variables inclusion or exclusion for modelling. It is important to consider the context, statistical

significance, multicollinearity, domain knowledge, and model performance when making decisions about variable selection for modeling.

The Heatmap above is difficult to interpret due to its size and the number of features within the dataset.

In [252…
```
# Correlation with target variable
cor_target = abs(cor['market_value_in_eur'])

# Selecting highly correlated features
relevant_features = cor_target[cor_target>0.4]
relevant_features
```

Out[252…
```
market_value_in_eur     1.000000
games_total             0.470027
goals_total             0.467667
assists_total           0.486171
minutes_played_total    0.471368
goals_for_total         0.545848
clean_sheet_total       0.519063
goals_for_2020          0.422572
games_2021              0.412321
goals_2021              0.413660
assists_2021            0.427364
minutes_played_2021     0.416458
goals_for_2021          0.495140
clean_sheet_2021        0.447354
games_2022              0.434351
goals_2022              0.457946
assists_2022            0.452212
minutes_played_2022     0.446138
goals_for_2022          0.518047
clean_sheet_2022        0.488459
goals_for_2023          0.406962
Name: market_value_in_eur, dtype: float64
```

Pearsons Correlation between selected categorical features (foot, position, sub_position, age_group)

In [253…
```
cor = df8_dummies_essential.corr()
```

In [254…
```
# Correlation with target variable
cor_target = abs(cor['market_value_in_eur'])

# Selecting highly correlated features
relevant_features = cor_target[cor_target>0.3]
relevant_features
```

Out[254…

```
market_value_in_eur        1.000000
remaining_contract_days    0.334212
games_total                0.470027
goals_total                0.467667
assists_total              0.486171
minutes_played_total       0.471368
goals_for_total            0.545848
goals_against_total        0.392081
clean_sheet_total          0.519063
yellow_cards_total         0.352771
games_2019                 0.319025
assists_2019               0.303601
minutes_played_2019        0.304588
goals_for_2019             0.365819
clean_sheet_2019           0.335958
games_2020                 0.361509
goals_2020                 0.349266
assists_2020               0.359543
minutes_played_2020        0.357576
goals_for_2020             0.422572
clean_sheet_2020           0.395995
games_2021                 0.412321
goals_2021                 0.413660
assists_2021               0.427364
minutes_played_2021        0.416458
goals_for_2021             0.495140
goals_against_2021         0.338094
clean_sheet_2021           0.447354
games_2022                 0.434351
goals_2022                 0.457946
assists_2022               0.452212
minutes_played_2022        0.446138
goals_for_2022             0.518047
goals_against_2022         0.312198
clean_sheet_2022           0.488459
yellow_cards_2022          0.314594
games_2023                 0.319920
goals_2023                 0.329007
minutes_played_2023        0.324534
goals_for_2023             0.406962
clean_sheet_2023           0.338500
Name: market_value_in_eur, dtype: float64
```

Surprisingly, categories such as foot, position, sub-positon and age-group do not seem to correlate highly with market-value.

Pearsons Correlation between All Features

In [255…

```
cor = df8_dummies_all.corr()
```

In [256…

```
# Correlation with target variable
cor_target = abs(cor['market_value_in_eur'])

# Selecting highly correlated features
relevant_features = cor_target[cor_target>0.1]
relevant_features
```

Out[256…

current_club_id	0.104776
market_value_in_eur	1.000000
remaining_contract_days	0.334212
games_total	0.470027
goals_total	0.467667
assists_total	0.486171
minutes_played_total	0.471368
goals_for_total	0.545848
goals_against_total	0.392081
clean_sheet_total	0.519063
yellow_cards_total	0.352771
red_cards_total	0.115185
games_2019	0.319025
goals_2019	0.297224
assists_2019	0.303601
minutes_played_2019	0.304588
goals_for_2019	0.365819
goals_against_2019	0.268493
clean_sheet_2019	0.335958
yellow_cards_2019	0.225521
games_2020	0.361509
goals_2020	0.349266
assists_2020	0.359543
minutes_played_2020	0.357576
goals_for_2020	0.422572
goals_against_2020	0.291681
clean_sheet_2020	0.395995
yellow_cards_2020	0.238545
games_2021	0.412321
goals_2021	0.413660
assists_2021	0.427364
minutes_played_2021	0.416458
goals_for_2021	0.495140
goals_against_2021	0.338094
clean_sheet_2021	0.447354
yellow_cards_2021	0.296076
games_2022	0.434351
goals_2022	0.457946
assists_2022	0.452212
minutes_played_2022	0.446138
goals_for_2022	0.518047
goals_against_2022	0.312198
clean_sheet_2022	0.488459
yellow_cards_2022	0.314594
games_2023	0.319920
goals_2023	0.329007
assists_2023	0.273764
minutes_played_2023	0.324534
goals_for_2023	0.406962
goals_against_2023	0.223611
clean_sheet_2023	0.338500
yellow_cards_2023	0.206615
last_season_2022	0.195083
last_season_2023	0.195083
current_club_domestic_competition_id_GB1	0.320959
current_club_name_Arsenal FC	0.160583
current_club_name_Bayern Munich	0.141541
current_club_name_Chelsea FC	0.148239
current_club_name_FC Barcelona	0.128979
current_club_name_Liverpool FC	0.138185

```
current_club_name_Manchester City           0.210800
current_club_name_Manchester United         0.118698
current_club_name_Paris Saint-Germain       0.172725
current_club_name_Real Madrid               0.159904
current_club_name_Tottenham Hotspur         0.106932
Name: market_value_in_eur, dtype: float64
```

Again, most categorical variables do not seem to have a high correlation with the target variable. The current domestic competition and playing for one of the larger clubs does however influence market value.

Feature Selection

All the above features with a correlation over 0.1 will be selected into a dataset for testing along with the full datasets.

In [257…
```
df8_dummies_all_fs = df8_dummies_all[['last_season_2022', 'last_season_2023', 'c
                                      'yellow_cards_total', 'red_cards_total', '
                                     'assists_2020', 'minutes_played_2020', 'goa
                                     'clean_sheet_2021', 'yellow_cards_2021', 'g
                                      'minutes_played_2023', 'goals_for_2023', '
                                     'current_club_name_Manchester City', 'curre
```

In [258…
```
df8_dummies_all_fs.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 10168 entries, 72 to 30129
Data columns (total 65 columns):
 #   Column                                    Non-Null Count  Dtype
---  ------                                    --------------  -----
 0   last_season_2022                          10168 non-null  int32
 1   last_season_2023                          10168 non-null  int32
 2   current_club_id                           10168 non-null  int64
 3   market_value_in_eur                       10168 non-null  float64
 4   remaining_contract_days                   10168 non-null  int32
 5   games_total                               10168 non-null  int64
 6   goals_total                               10168 non-null  int64
 7   assists_total                             10168 non-null  int64
 8   minutes_played_total                      10168 non-null  int64
 9   goals_for_total                           10168 non-null  int64
 10  goals_against_total                       10168 non-null  int64
 11  clean_sheet_total                         10168 non-null  int64
 12  yellow_cards_total                        10168 non-null  int64
 13  red_cards_total                           10168 non-null  int64
 14  games_2019                                10168 non-null  int32
 15  goals_2019                                10168 non-null  int32
 16  assists_2019                              10168 non-null  int32
 17  minutes_played_2019                       10168 non-null  int32
 18  goals_for_2019                            10168 non-null  int32
 19  goals_against_2019                        10168 non-null  int32
 20  clean_sheet_2019                          10168 non-null  int32
 21  yellow_cards_2019                         10168 non-null  int32
 22  games_2020                                10168 non-null  int32
 23  goals_2020                                10168 non-null  int32
 24  assists_2020                              10168 non-null  int32
 25  minutes_played_2020                       10168 non-null  int32
 26  goals_for_2020                            10168 non-null  int32
 27  goals_against_2020                        10168 non-null  int32
 28  clean_sheet_2020                          10168 non-null  int32
 29  yellow_cards_2020                         10168 non-null  int32
 30  games_2021                                10168 non-null  int32
 31  goals_2021                                10168 non-null  int32
 32  assists_2021                              10168 non-null  int32
 33  minutes_played_2021                       10168 non-null  int32
 34  goals_for_2021                            10168 non-null  int32
 35  goals_against_2021                        10168 non-null  int32
 36  clean_sheet_2021                          10168 non-null  int32
 37  yellow_cards_2021                         10168 non-null  int32
 38  games_2022                                10168 non-null  int32
 39  goals_2022                                10168 non-null  int64
 40  assists_2022                              10168 non-null  int64
 41  minutes_played_2022                       10168 non-null  int32
 42  goals_for_2022                            10168 non-null  int32
 43  goals_against_2022                        10168 non-null  int32
 44  clean_sheet_2022                          10168 non-null  int64
 45  yellow_cards_2022                         10168 non-null  int64
 46  games_2023                                10168 non-null  int32
 47  goals_2023                                10168 non-null  int32
 48  assists_2023                              10168 non-null  int32
 49  minutes_played_2023                       10168 non-null  int32
 50  goals_for_2023                            10168 non-null  int32
 51  goals_against_2023                        10168 non-null  int32
 52  clean_sheet_2023                          10168 non-null  int32
 53  yellow_cards_2023                         10168 non-null  int32
 54  current_club_domestic_competition_id_GB1  10168 non-null  int32
```

```
 55  current_club_name_Arsenal FC              10168 non-null  int32
 56  current_club_name_Bayern Munich           10168 non-null  int32
 57  current_club_name_Chelsea FC              10168 non-null  int32
 58  current_club_name_FC Barcelona            10168 non-null  int32
 59  current_club_name_Liverpool FC            10168 non-null  int32
 60  current_club_name_Manchester City         10168 non-null  int32
 61  current_club_name_Manchester United       10168 non-null  int32
 62  current_club_name_Paris Saint-Germain     10168 non-null  int32
 63  current_club_name_Real Madrid             10168 non-null  int32
 64  current_club_name_Tottenham Hotspur       10168 non-null  int32
dtypes: float64(1), int32(50), int64(14)
memory usage: 3.2 MB
```

Scaling the Data

Both standard and robust scalers transform inputs to comparable scales. The difference lies in how they scale raw input values. Standard scaling uses mean and standard deviation. MinMax Scaler is often used as an alternative to Standard Scaler if zero mean and unit variance want to be avoided. Robust scaling uses median and interquartile range (IQR) instead. As the data contains a range of numbers and outliers, Robust scaler would be the prefered choice but MinMaxScaler method will also be applied for comparative purposes as it accounts for mean and unit variance.

In [259…

```
numerical_features_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 10168 entries, 72 to 30129
Data columns (total 71 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   current_club_id          10168 non-null  int64
 1   height_in_cm             10168 non-null  float64
 2   market_value_in_eur      10168 non-null  float64
 3   age                      10168 non-null  int64
 4   remaining_contract_days  10168 non-null  int32
 5   games_total              10168 non-null  int64
 6   goals_total              10168 non-null  int64
 7   assists_total            10168 non-null  int64
 8   minutes_played_total     10168 non-null  int64
 9   goals_for_total          10168 non-null  int64
 10  goals_against_total      10168 non-null  int64
 11  clean_sheet_total        10168 non-null  int64
 12  yellow_cards_total       10168 non-null  int64
 13  red_cards_total          10168 non-null  int64
 14  games_2019               10168 non-null  int32
 15  goals_2019               10168 non-null  int32
 16  assists_2019             10168 non-null  int32
 17  minutes_played_2019      10168 non-null  int32
 18  goals_for_2019           10168 non-null  int32
 19  goals_against_2019       10168 non-null  int32
 20  clean_sheet_2019         10168 non-null  int32
 21  yellow_cards_2019        10168 non-null  int32
 22  red_cards_2019           10168 non-null  int32
 23  games_2020               10168 non-null  int32
 24  goals_2020               10168 non-null  int32
 25  assists_2020             10168 non-null  int32
 26  minutes_played_2020      10168 non-null  int32
 27  goals_for_2020           10168 non-null  int32
 28  goals_against_2020       10168 non-null  int32
 29  clean_sheet_2020         10168 non-null  int32
 30  yellow_cards_2020        10168 non-null  int32
 31  red_cards_2020           10168 non-null  int32
 32  games_2021               10168 non-null  int32
 33  goals_2021               10168 non-null  int32
 34  assists_2021             10168 non-null  int32
 35  minutes_played_2021      10168 non-null  int32
 36  goals_for_2021           10168 non-null  int32
 37  goals_against_2021       10168 non-null  int32
 38  clean_sheet_2021         10168 non-null  int32
 39  yellow_cards_2021        10168 non-null  int32
 40  red_cards_2021           10168 non-null  int32
 41  games_2022               10168 non-null  int32
 42  goals_2022               10168 non-null  int64
 43  assists_2022             10168 non-null  int64
 44  minutes_played_2022      10168 non-null  int32
 45  goals_for_2022           10168 non-null  int32
 46  goals_against_2022       10168 non-null  int32
 47  clean_sheet_2022         10168 non-null  int64
 48  yellow_cards_2022        10168 non-null  int64
 49  red_cards_2022           10168 non-null  int64
 50  games_2023               10168 non-null  int32
 51  goals_2023               10168 non-null  int32
 52  assists_2023             10168 non-null  int32
 53  minutes_played_2023      10168 non-null  int32
 54  goals_for_2023           10168 non-null  int32
```

```
 55  goals_against_2023        10168 non-null  int32
 56  clean_sheet_2023          10168 non-null  int32
 57  yellow_cards_2023         10168 non-null  int32
 58  red_cards_2023            10168 non-null  int32
 59  mins_per_goal_2023        10168 non-null  float64
 60  mins_per_goal_2022        10168 non-null  float64
 61  mins_per_goal_2021        10168 non-null  float64
 62  mins_per_goal_2020        10168 non-null  float64
 63  mins_per_goal_2019        10168 non-null  float64
 64  mins_per_goal_total       10168 non-null  float64
 65  mins_per_assist_2023      10168 non-null  float64
 66  mins_per_assist_2022      10168 non-null  float64
 67  mins_per_assist_2021      10168 non-null  float64
 68  mins_per_assist_2020      10168 non-null  float64
 69  mins_per_assist_2019      10168 non-null  float64
 70  mins_per_assist_total     10168 non-null  float64
dtypes: float64(14), int32(41), int64(16)
memory usage: 4.0 MB
```

In [260…
```
numerical_features_df.describe()
```

Out[260…

	current_club_id	height_in_cm	market_value_in_eur	age	remaining_cont
count	10168.000000	10168.000000	1.016800e+04	10168.000000	101
mean	4836.920437	182.662866	3.884016e+06	25.857887	6
std	12192.771146	6.803874	9.808620e+06	4.861793	4
min	3.000000	160.000000	1.000000e+04	16.000000	-2
25%	370.000000	178.000000	3.000000e+05	22.000000	1
50%	985.000000	183.000000	8.000000e+05	25.000000	5
75%	2778.000000	187.966463	2.800000e+06	29.000000	9
max	83678.000000	206.000000	1.800000e+08	43.000000	31

In [261…
```
numerical_features_df.head()
```

Out[261…

	current_club_id	height_in_cm	market_value_in_eur	age	remaining_contract_days
72	418	185.0	25000000.0	36	923
88	678	188.0	200000.0	39	193
117	367	180.0	2500000.0	36	193
132	1095	184.0	200000.0	38	609
135	1519	185.0	200000.0	37	609

MinMaxScaler

In [264…
```
# Removing feature with nuerical values that are too large for scaling
numerical_features_df_4_midmax = numerical_features_df.drop(['mins_per_goal_2023
```

In [265…

```
numerical_features_df_4_midmax.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 10168 entries, 72 to 30129
Data columns (total 59 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   current_club_id          10168 non-null  int64
 1   height_in_cm             10168 non-null  float64
 2   market_value_in_eur      10168 non-null  float64
 3   age                      10168 non-null  int64
 4   remaining_contract_days  10168 non-null  int32
 5   games_total              10168 non-null  int64
 6   goals_total              10168 non-null  int64
 7   assists_total            10168 non-null  int64
 8   minutes_played_total     10168 non-null  int64
 9   goals_for_total          10168 non-null  int64
 10  goals_against_total      10168 non-null  int64
 11  clean_sheet_total        10168 non-null  int64
 12  yellow_cards_total       10168 non-null  int64
 13  red_cards_total          10168 non-null  int64
 14  games_2019               10168 non-null  int32
 15  goals_2019               10168 non-null  int32
 16  assists_2019             10168 non-null  int32
 17  minutes_played_2019      10168 non-null  int32
 18  goals_for_2019           10168 non-null  int32
 19  goals_against_2019       10168 non-null  int32
 20  clean_sheet_2019         10168 non-null  int32
 21  yellow_cards_2019        10168 non-null  int32
 22  red_cards_2019           10168 non-null  int32
 23  games_2020               10168 non-null  int32
 24  goals_2020               10168 non-null  int32
 25  assists_2020             10168 non-null  int32
 26  minutes_played_2020      10168 non-null  int32
 27  goals_for_2020           10168 non-null  int32
 28  goals_against_2020       10168 non-null  int32
 29  clean_sheet_2020         10168 non-null  int32
 30  yellow_cards_2020        10168 non-null  int32
 31  red_cards_2020           10168 non-null  int32
 32  games_2021               10168 non-null  int32
 33  goals_2021               10168 non-null  int32
 34  assists_2021             10168 non-null  int32
 35  minutes_played_2021      10168 non-null  int32
 36  goals_for_2021           10168 non-null  int32
 37  goals_against_2021       10168 non-null  int32
 38  clean_sheet_2021         10168 non-null  int32
 39  yellow_cards_2021        10168 non-null  int32
 40  red_cards_2021           10168 non-null  int32
 41  games_2022               10168 non-null  int32
 42  goals_2022               10168 non-null  int64
 43  assists_2022             10168 non-null  int64
 44  minutes_played_2022      10168 non-null  int32
 45  goals_for_2022           10168 non-null  int32
 46  goals_against_2022       10168 non-null  int32
 47  clean_sheet_2022         10168 non-null  int64
 48  yellow_cards_2022        10168 non-null  int64
 49  red_cards_2022           10168 non-null  int64
 50  games_2023               10168 non-null  int32
 51  goals_2023               10168 non-null  int32
 52  assists_2023             10168 non-null  int32
 53  minutes_played_2023      10168 non-null  int32
 54  goals_for_2023           10168 non-null  int32
```

```
 55  goals_against_2023       10168 non-null  int32
 56  clean_sheet_2023         10168 non-null  int32
 57  yellow_cards_2023        10168 non-null  int32
 58  red_cards_2023           10168 non-null  int32
dtypes: float64(2), int32(41), int64(16)
memory usage: 3.1 MB
```

In [272…
```
numerical_features_df_4_midmax.columns
```

Out[272…
```
Index(['current_club_id', 'height_in_cm', 'market_value_in_eur', 'age',
       'remaining_contract_days', 'games_total', 'goals_total',
       'assists_total', 'minutes_played_total', 'goals_for_total',
       'goals_against_total', 'clean_sheet_total', 'yellow_cards_total',
       'red_cards_total', 'games_2019', 'goals_2019', 'assists_2019',
       'minutes_played_2019', 'goals_for_2019', 'goals_against_2019',
       'clean_sheet_2019', 'yellow_cards_2019', 'red_cards_2019', 'games_2020',
       'goals_2020', 'assists_2020', 'minutes_played_2020', 'goals_for_2020',
       'goals_against_2020', 'clean_sheet_2020', 'yellow_cards_2020',
       'red_cards_2020', 'games_2021', 'goals_2021', 'assists_2021',
       'minutes_played_2021', 'goals_for_2021', 'goals_against_2021',
       'clean_sheet_2021', 'yellow_cards_2021', 'red_cards_2021', 'games_2022',
       'goals_2022', 'assists_2022', 'minutes_played_2022', 'goals_for_2022',
       'goals_against_2022', 'clean_sheet_2022', 'yellow_cards_2022',
       'red_cards_2022', 'games_2023', 'goals_2023', 'assists_2023',
       'minutes_played_2023', 'goals_for_2023', 'goals_against_2023',
       'clean_sheet_2023', 'yellow_cards_2023', 'red_cards_2023'],
      dtype='object')
```

In [262…
```
# Creating a MinMaxSCaler object
mmscaler = MinMaxScaler()
```

In [266…
```
# Train the MinMaxSCaler model
mmscaler.fit(numerical_features_df_4_midmax)
```

Out[266…
```
▾ MinMaxScaler

MinMaxScaler()
```

In [268…
```
# Transform the data

numerical_features_df_4_midmax_scaled = mmscaler.transform(numerical_features_df
```

Concatenating dateframes following scaling for numerical categories

In [308…
```
numerical_features_df_4_midmax_scaled.shape
```

Out[308…
```
(10168, 59)
```

In [276…
```
numerical_features_df_4_midmax_scaled = pd.DataFrame(numerical_features_df_4_mid
       'remaining_contract_days', 'games_total', 'goals_total',
       'assists_total', 'minutes_played_total', 'goals_for_total',
       'goals_against_total', 'clean_sheet_total', 'yellow_cards_total',
       'red_cards_total', 'games_2019', 'goals_2019', 'assists_2019',
       'minutes_played_2019', 'goals_for_2019', 'goals_against_2019',
       'clean_sheet_2019', 'yellow_cards_2019', 'red_cards_2019', 'games_2020',
       'goals_2020', 'assists_2020', 'minutes_played_2020', 'goals_for_2020',
       'goals_against_2020', 'clean_sheet_2020', 'yellow_cards_2020',
       'red_cards_2020', 'games_2021', 'goals_2021', 'assists_2021',
```

```
       'minutes_played_2021', 'goals_for_2021', 'goals_against_2021',
       'clean_sheet_2021', 'yellow_cards_2021', 'red_cards_2021', 'games_2022',
       'goals_2022', 'assists_2022', 'minutes_played_2022', 'goals_for_2022',
       'goals_against_2022', 'clean_sheet_2022', 'yellow_cards_2022',
       'red_cards_2022', 'games_2023', 'goals_2023', 'assists_2023',
       'minutes_played_2023', 'goals_for_2023', 'goals_against_2023',
       'clean_sheet_2023', 'yellow_cards_2023', 'red_cards_2023'])
```

In [309…
```
dummies_df_essential_cats.shape
```

Out[309…
```
(10168, 27)
```

In [312…
```
numerical_features_df_4_midmax_scaled.reset_index(drop=True, inplace=True)
dummies_df_essential_cats.reset_index(drop=True, inplace=True)

df8_dummies_essential_mm_scaled = pd.concat([numerical_features_df_4_midmax_scal
```

In [313…
```
#df8_dummies_essential_mm_scaled = pd.concat([numerical_features_df_4_midmax_sca
```

In [314…
```
df8_dummies_essential_mm_scaled.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10168 entries, 0 to 10167
Data columns (total 86 columns):
 #   Column                          Non-Null Count  Dtype  
---  ------                          --------------  -----  
 0   current_club_id                 10168 non-null  float64
 1   height_in_cm                    10168 non-null  float64
 2   market_value_in_eur             10168 non-null  float64
 3   age                             10168 non-null  float64
 4   remaining_contract_days         10168 non-null  float64
 5   games_total                     10168 non-null  float64
 6   goals_total                     10168 non-null  float64
 7   assists_total                   10168 non-null  float64
 8   minutes_played_total            10168 non-null  float64
 9   goals_for_total                 10168 non-null  float64
 10  goals_against_total             10168 non-null  float64
 11  clean_sheet_total               10168 non-null  float64
 12  yellow_cards_total              10168 non-null  float64
 13  red_cards_total                 10168 non-null  float64
 14  games_2019                      10168 non-null  float64
 15  goals_2019                      10168 non-null  float64
 16  assists_2019                    10168 non-null  float64
 17  minutes_played_2019             10168 non-null  float64
 18  goals_for_2019                  10168 non-null  float64
 19  goals_against_2019              10168 non-null  float64
 20  clean_sheet_2019                10168 non-null  float64
 21  yellow_cards_2019               10168 non-null  float64
 22  red_cards_2019                  10168 non-null  float64
 23  games_2020                      10168 non-null  float64
 24  goals_2020                      10168 non-null  float64
 25  assists_2020                    10168 non-null  float64
 26  minutes_played_2020             10168 non-null  float64
 27  goals_for_2020                  10168 non-null  float64
 28  goals_against_2020              10168 non-null  float64
 29  clean_sheet_2020                10168 non-null  float64
 30  yellow_cards_2020               10168 non-null  float64
 31  red_cards_2020                  10168 non-null  float64
 32  games_2021                      10168 non-null  float64
 33  goals_2021                      10168 non-null  float64
 34  assists_2021                    10168 non-null  float64
 35  minutes_played_2021             10168 non-null  float64
 36  goals_for_2021                  10168 non-null  float64
 37  goals_against_2021              10168 non-null  float64
 38  clean_sheet_2021                10168 non-null  float64
 39  yellow_cards_2021               10168 non-null  float64
 40  red_cards_2021                  10168 non-null  float64
 41  games_2022                      10168 non-null  float64
 42  goals_2022                      10168 non-null  float64
 43  assists_2022                    10168 non-null  float64
 44  minutes_played_2022             10168 non-null  float64
 45  goals_for_2022                  10168 non-null  float64
 46  goals_against_2022              10168 non-null  float64
 47  clean_sheet_2022                10168 non-null  float64
 48  yellow_cards_2022               10168 non-null  float64
 49  red_cards_2022                  10168 non-null  float64
 50  games_2023                      10168 non-null  float64
 51  goals_2023                      10168 non-null  float64
 52  assists_2023                    10168 non-null  float64
 53  minutes_played_2023             10168 non-null  float64
 54  goals_for_2023                  10168 non-null  float64
```

```
 55  goals_against_2023                10168 non-null  float64
 56  clean_sheet_2023                  10168 non-null  float64
 57  yellow_cards_2023                 10168 non-null  float64
 58  red_cards_2023                    10168 non-null  float64
 59  last_season_2022                  10168 non-null  int32
 60  last_season_2023                  10168 non-null  int32
 61  sub_position_Attacking Midfield   10168 non-null  int32
 62  sub_position_Central Midfield     10168 non-null  int32
 63  sub_position_Centre-Back          10168 non-null  int32
 64  sub_position_Centre-Forward       10168 non-null  int32
 65  sub_position_Defensive Midfield   10168 non-null  int32
 66  sub_position_Goalkeeper           10168 non-null  int32
 67  sub_position_Left Midfield        10168 non-null  int32
 68  sub_position_Left Winger          10168 non-null  int32
 69  sub_position_Left-Back            10168 non-null  int32
 70  sub_position_Right Midfield       10168 non-null  int32
 71  sub_position_Right Winger         10168 non-null  int32
 72  sub_position_Right-Back           10168 non-null  int32
 73  sub_position_Second Striker       10168 non-null  int32
 74  position_Attack                   10168 non-null  int32
 75  position_Defender                 10168 non-null  int32
 76  position_Goalkeeper               10168 non-null  int32
 77  position_Midfield                 10168 non-null  int32
 78  foot_both                         10168 non-null  int32
 79  foot_left                         10168 non-null  int32
 80  foot_right                        10168 non-null  int32
 81  age_group_Ages 22 - 26            10168 non-null  int32
 82  age_group_Ages 27 - 32            10168 non-null  int32
 83  age_group_Ages 33 - 38            10168 non-null  int32
 84  age_group_Ages 39 - 44            10168 non-null  int32
 85  age_group_Ages Under 22           10168 non-null  int32
dtypes: float64(59), int32(27)
memory usage: 5.6 MB
```

In [315…
```
df8_dummies_essential_mm_scaled.shape
```

Out[315…
```
(10168, 86)
```

In [316…
```
all_dummies.reset_index(drop=True, inplace=True)

df8_dummies_all_mm_scaled = pd.concat([numerical_features_df_4_midmax_scaled, al
```

In [317…
```
df8_dummies_all_mm_scaled.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10168 entries, 0 to 10167
Columns: 374 entries, current_club_id to current_club_name_Ümraniyespor
dtypes: float64(59), int32(315)
memory usage: 16.8 MB
```

Categorical Features :['last_season','sub_position', 'position', 'foot', 'current_club_domestic_competition_id', 'current_club_name', 'age_group']

In [320…
```
df8_dummies_all_fs_mm_scaled = numerical_features_df_4_midmax_scaled[['current_c
                                        'yellow_cards_total', 'red_cards_total', '
                                       'assists_2020', 'minutes_played_2020', 'goa
                                       'clean_sheet_2021', 'yellow_cards_2021', 'g
                                        'minutes_played_2023', 'goals_for_2023', '
```

In [321…
```
feature_selected_dummies = all_dummies[['last_season_2022', 'last_season_2023',
                                        'current_club_name_Manchester City', 'curre
```

In [322…
```
df8_dummies_all_fs_mm_scaled.reset_index(drop=True, inplace=True)
feature_selected_dummies.reset_index(drop=True, inplace=True)

df8_dummies_all_fs_mm_scaled = pd.concat([df8_dummies_all_fs_mm_scaled, feature_
```

In [323…
```
df8_dummies_all_fs_mm_scaled.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10168 entries, 0 to 10167
Data columns (total 65 columns):
 #   Column                                    Non-Null Count  Dtype
---  ------                                    --------------  -----
 0   current_club_id                           10168 non-null  float64
 1   market_value_in_eur                       10168 non-null  float64
 2   remaining_contract_days                   10168 non-null  float64
 3   games_total                               10168 non-null  float64
 4   goals_total                               10168 non-null  float64
 5   assists_total                             10168 non-null  float64
 6   minutes_played_total                      10168 non-null  float64
 7   goals_for_total                           10168 non-null  float64
 8   goals_against_total                       10168 non-null  float64
 9   clean_sheet_total                         10168 non-null  float64
 10  yellow_cards_total                        10168 non-null  float64
 11  red_cards_total                           10168 non-null  float64
 12  games_2019                                10168 non-null  float64
 13  goals_2019                                10168 non-null  float64
 14  assists_2019                              10168 non-null  float64
 15  minutes_played_2019                       10168 non-null  float64
 16  goals_for_2019                            10168 non-null  float64
 17  goals_against_2019                        10168 non-null  float64
 18  clean_sheet_2019                          10168 non-null  float64
 19  yellow_cards_2019                         10168 non-null  float64
 20  games_2020                                10168 non-null  float64
 21  goals_2020                                10168 non-null  float64
 22  assists_2020                              10168 non-null  float64
 23  minutes_played_2020                       10168 non-null  float64
 24  goals_for_2020                            10168 non-null  float64
 25  goals_against_2020                        10168 non-null  float64
 26  clean_sheet_2020                          10168 non-null  float64
 27  yellow_cards_2020                         10168 non-null  float64
 28  games_2021                                10168 non-null  float64
 29  goals_2021                                10168 non-null  float64
 30  assists_2021                              10168 non-null  float64
 31  minutes_played_2021                       10168 non-null  float64
 32  goals_for_2021                            10168 non-null  float64
 33  goals_against_2021                        10168 non-null  float64
 34  clean_sheet_2021                          10168 non-null  float64
 35  yellow_cards_2021                         10168 non-null  float64
 36  games_2022                                10168 non-null  float64
 37  goals_2022                                10168 non-null  float64
 38  assists_2022                              10168 non-null  float64
 39  minutes_played_2022                       10168 non-null  float64
 40  goals_for_2022                            10168 non-null  float64
 41  goals_against_2022                        10168 non-null  float64
 42  clean_sheet_2022                          10168 non-null  float64
 43  yellow_cards_2022                         10168 non-null  float64
 44  games_2023                                10168 non-null  float64
 45  goals_2023                                10168 non-null  float64
 46  assists_2023                              10168 non-null  float64
 47  minutes_played_2023                       10168 non-null  float64
 48  goals_for_2023                            10168 non-null  float64
 49  goals_against_2023                        10168 non-null  float64
 50  clean_sheet_2023                          10168 non-null  float64
 51  yellow_cards_2023                         10168 non-null  float64
 52  last_season_2022                          10168 non-null  int32
 53  last_season_2023                          10168 non-null  int32
 54  current_club_domestic_competition_id_GB1  10168 non-null  int32
```

```
 55  current_club_name_Arsenal FC              10168 non-null  int32
 56  current_club_name_Bayern Munich           10168 non-null  int32
 57  current_club_name_Chelsea FC              10168 non-null  int32
 58  current_club_name_FC Barcelona            10168 non-null  int32
 59  current_club_name_Liverpool FC            10168 non-null  int32
 60  current_club_name_Manchester City         10168 non-null  int32
 61  current_club_name_Manchester United       10168 non-null  int32
 62  current_club_name_Paris Saint-Germain     10168 non-null  int32
 63  current_club_name_Real Madrid             10168 non-null  int32
 64  current_club_name_Tottenham Hotspur       10168 non-null  int32
dtypes: float64(52), int32(13)
memory usage: 4.5 MB
```

In [324…
```
df8_dummies_all_fs_mm_scaled.describe()
```

Out[324…

	current_club_id	market_value_in_eur	remaining_contract_days	games_total	g
count	10168.000000	10168.000000	10168.000000	10168.000000	101
mean	0.057770	0.021524	0.244843	0.217469	
std	0.145716	0.054495	0.129935	0.223635	
min	0.000000	0.000000	0.000000	0.000000	
25%	0.004386	0.001611	0.119349	0.023256	
50%	0.011736	0.004389	0.229355	0.139535	
75%	0.033164	0.015501	0.339361	0.367442	
max	1.000000	1.000000	1.000000	1.000000	

Robust Scaler

As with the MidMaxScaler, Robust scaler does not seem to work with the features generated with large (infinity like) values. We will scale the remaining numerical features.

In [325…
```
# Creating a RobustScaler object
rbscaler = RobustScaler()
```

In [326…
```
# Train the RobustScaler model
rbscaler.fit(numerical_features_df_4_midmax)
```

Out[326…
```
▾ RobustScaler
RobustScaler()
```

In [327…
```
# Transform the data
numerical_features_df_rb_scaled = rbscaler.transform(numerical_features_df_4_mid
```

Concatenating dateframes following robust scaling of numerical categories

In [328…
```
numerical_features_df_rb_scaled = pd.DataFrame(numerical_features_df_rb_scaled,
       'remaining_contract_days', 'games_total', 'goals_total',
```

```
       'assists_total', 'minutes_played_total', 'goals_for_total',
       'goals_against_total', 'clean_sheet_total', 'yellow_cards_total',
       'red_cards_total', 'games_2019', 'goals_2019', 'assists_2019',
       'minutes_played_2019', 'goals_for_2019', 'goals_against_2019',
       'clean_sheet_2019', 'yellow_cards_2019', 'red_cards_2019', 'games_2020',
       'goals_2020', 'assists_2020', 'minutes_played_2020', 'goals_for_2020',
       'goals_against_2020', 'clean_sheet_2020', 'yellow_cards_2020',
       'red_cards_2020', 'games_2021', 'goals_2021', 'assists_2021',
       'minutes_played_2021', 'goals_for_2021', 'goals_against_2021',
       'clean_sheet_2021', 'yellow_cards_2021', 'red_cards_2021', 'games_2022',
       'goals_2022', 'assists_2022', 'minutes_played_2022', 'goals_for_2022',
       'goals_against_2022', 'clean_sheet_2022', 'yellow_cards_2022',
       'red_cards_2022', 'games_2023', 'goals_2023', 'assists_2023',
       'minutes_played_2023', 'goals_for_2023', 'goals_against_2023',
       'clean_sheet_2023', 'yellow_cards_2023', 'red_cards_2023'])
```

In [329…

```
numerical_features_df_rb_scaled.reset_index(drop=True, inplace=True)
dummies_df_essential_cats.reset_index(drop=True, inplace=True)

df8_dummies_essential_rb_scaled = pd.concat([numerical_features_df_rb_scaled, du
```

In [330…

```
df8_dummies_essential_rb_scaled.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10168 entries, 0 to 10167
Data columns (total 86 columns):
 #   Column                          Non-Null Count  Dtype  
---  ------                          --------------  -----  
 0   current_club_id                 10168 non-null  float64
 1   height_in_cm                    10168 non-null  float64
 2   market_value_in_eur             10168 non-null  float64
 3   age                             10168 non-null  float64
 4   remaining_contract_days         10168 non-null  float64
 5   games_total                     10168 non-null  float64
 6   goals_total                     10168 non-null  float64
 7   assists_total                   10168 non-null  float64
 8   minutes_played_total            10168 non-null  float64
 9   goals_for_total                 10168 non-null  float64
 10  goals_against_total             10168 non-null  float64
 11  clean_sheet_total               10168 non-null  float64
 12  yellow_cards_total              10168 non-null  float64
 13  red_cards_total                 10168 non-null  float64
 14  games_2019                      10168 non-null  float64
 15  goals_2019                      10168 non-null  float64
 16  assists_2019                    10168 non-null  float64
 17  minutes_played_2019             10168 non-null  float64
 18  goals_for_2019                  10168 non-null  float64
 19  goals_against_2019              10168 non-null  float64
 20  clean_sheet_2019                10168 non-null  float64
 21  yellow_cards_2019               10168 non-null  float64
 22  red_cards_2019                  10168 non-null  float64
 23  games_2020                      10168 non-null  float64
 24  goals_2020                      10168 non-null  float64
 25  assists_2020                    10168 non-null  float64
 26  minutes_played_2020             10168 non-null  float64
 27  goals_for_2020                  10168 non-null  float64
 28  goals_against_2020              10168 non-null  float64
 29  clean_sheet_2020                10168 non-null  float64
 30  yellow_cards_2020               10168 non-null  float64
 31  red_cards_2020                  10168 non-null  float64
 32  games_2021                      10168 non-null  float64
 33  goals_2021                      10168 non-null  float64
 34  assists_2021                    10168 non-null  float64
 35  minutes_played_2021             10168 non-null  float64
 36  goals_for_2021                  10168 non-null  float64
 37  goals_against_2021              10168 non-null  float64
 38  clean_sheet_2021                10168 non-null  float64
 39  yellow_cards_2021               10168 non-null  float64
 40  red_cards_2021                  10168 non-null  float64
 41  games_2022                      10168 non-null  float64
 42  goals_2022                      10168 non-null  float64
 43  assists_2022                    10168 non-null  float64
 44  minutes_played_2022             10168 non-null  float64
 45  goals_for_2022                  10168 non-null  float64
 46  goals_against_2022              10168 non-null  float64
 47  clean_sheet_2022                10168 non-null  float64
 48  yellow_cards_2022               10168 non-null  float64
 49  red_cards_2022                  10168 non-null  float64
 50  games_2023                      10168 non-null  float64
 51  goals_2023                      10168 non-null  float64
 52  assists_2023                    10168 non-null  float64
 53  minutes_played_2023             10168 non-null  float64
 54  goals_for_2023                  10168 non-null  float64
```

```
 55  goals_against_2023                10168 non-null  float64
 56  clean_sheet_2023                  10168 non-null  float64
 57  yellow_cards_2023                 10168 non-null  float64
 58  red_cards_2023                    10168 non-null  float64
 59  last_season_2022                  10168 non-null  int32
 60  last_season_2023                  10168 non-null  int32
 61  sub_position_Attacking Midfield   10168 non-null  int32
 62  sub_position_Central Midfield     10168 non-null  int32
 63  sub_position_Centre-Back          10168 non-null  int32
 64  sub_position_Centre-Forward       10168 non-null  int32
 65  sub_position_Defensive Midfield   10168 non-null  int32
 66  sub_position_Goalkeeper           10168 non-null  int32
 67  sub_position_Left Midfield        10168 non-null  int32
 68  sub_position_Left Winger          10168 non-null  int32
 69  sub_position_Left-Back            10168 non-null  int32
 70  sub_position_Right Midfield       10168 non-null  int32
 71  sub_position_Right Winger         10168 non-null  int32
 72  sub_position_Right-Back           10168 non-null  int32
 73  sub_position_Second Striker       10168 non-null  int32
 74  position_Attack                   10168 non-null  int32
 75  position_Defender                 10168 non-null  int32
 76  position_Goalkeeper               10168 non-null  int32
 77  position_Midfield                 10168 non-null  int32
 78  foot_both                         10168 non-null  int32
 79  foot_left                         10168 non-null  int32
 80  foot_right                        10168 non-null  int32
 81  age_group_Ages 22 - 26            10168 non-null  int32
 82  age_group_Ages 27 - 32            10168 non-null  int32
 83  age_group_Ages 33 - 38            10168 non-null  int32
 84  age_group_Ages 39 - 44            10168 non-null  int32
 85  age_group_Ages Under 22           10168 non-null  int32
dtypes: float64(59), int32(27)
memory usage: 5.6 MB
```

In [331…
```
all_dummies.reset_index(drop=True, inplace=True)
df8_dummies_all_rb_scaled = pd.concat([numerical_features_df_rb_scaled, all_dumm
```

In [332…
```
df8_dummies_all_rb_scaled.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10168 entries, 0 to 10167
Columns: 374 entries, current_club_id to current_club_name_Ümraniyespor
dtypes: float64(59), int32(315)
memory usage: 16.8 MB
```

In [333…
```
df8_dummies_all_fs_rb_scaled = numerical_features_df_rb_scaled[['current_club_id
                                        'yellow_cards_total', 'red_cards_total', '
                                       'assists_2020', 'minutes_played_2020', 'goa
                                       'clean_sheet_2021', 'yellow_cards_2021', 'g
                                        'minutes_played_2023', 'goals_for_2023', '
```

In [334…
```
df8_dummies_all_fs_rb_scaled.reset_index(drop=True, inplace=True)
feature_selected_dummies.reset_index(drop=True, inplace=True)

df8_dummies_all_fs_rb_scaled = pd.concat([df8_dummies_all_fs_rb_scaled, feature_
```

In [335…
```
df8_dummies_all_fs_rb_scaled.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10168 entries, 0 to 10167
Data columns (total 65 columns):
 #   Column                                    Non-Null Count  Dtype
---  ------                                    --------------  -----
 0   current_club_id                           10168 non-null  float64
 1   market_value_in_eur                       10168 non-null  float64
 2   remaining_contract_days                   10168 non-null  float64
 3   games_total                               10168 non-null  float64
 4   goals_total                               10168 non-null  float64
 5   assists_total                             10168 non-null  float64
 6   minutes_played_total                      10168 non-null  float64
 7   goals_for_total                           10168 non-null  float64
 8   goals_against_total                       10168 non-null  float64
 9   clean_sheet_total                         10168 non-null  float64
 10  yellow_cards_total                        10168 non-null  float64
 11  red_cards_total                           10168 non-null  float64
 12  games_2019                                10168 non-null  float64
 13  goals_2019                                10168 non-null  float64
 14  assists_2019                              10168 non-null  float64
 15  minutes_played_2019                       10168 non-null  float64
 16  goals_for_2019                            10168 non-null  float64
 17  goals_against_2019                        10168 non-null  float64
 18  clean_sheet_2019                          10168 non-null  float64
 19  yellow_cards_2019                         10168 non-null  float64
 20  games_2020                                10168 non-null  float64
 21  goals_2020                                10168 non-null  float64
 22  assists_2020                              10168 non-null  float64
 23  minutes_played_2020                       10168 non-null  float64
 24  goals_for_2020                            10168 non-null  float64
 25  goals_against_2020                        10168 non-null  float64
 26  clean_sheet_2020                          10168 non-null  float64
 27  yellow_cards_2020                         10168 non-null  float64
 28  games_2021                                10168 non-null  float64
 29  goals_2021                                10168 non-null  float64
 30  assists_2021                              10168 non-null  float64
 31  minutes_played_2021                       10168 non-null  float64
 32  goals_for_2021                            10168 non-null  float64
 33  goals_against_2021                        10168 non-null  float64
 34  clean_sheet_2021                          10168 non-null  float64
 35  yellow_cards_2021                         10168 non-null  float64
 36  games_2022                                10168 non-null  float64
 37  goals_2022                                10168 non-null  float64
 38  assists_2022                              10168 non-null  float64
 39  minutes_played_2022                       10168 non-null  float64
 40  goals_for_2022                            10168 non-null  float64
 41  goals_against_2022                        10168 non-null  float64
 42  clean_sheet_2022                          10168 non-null  float64
 43  yellow_cards_2022                         10168 non-null  float64
 44  games_2023                                10168 non-null  float64
 45  goals_2023                                10168 non-null  float64
 46  assists_2023                              10168 non-null  float64
 47  minutes_played_2023                       10168 non-null  float64
 48  goals_for_2023                            10168 non-null  float64
 49  goals_against_2023                        10168 non-null  float64
 50  clean_sheet_2023                          10168 non-null  float64
 51  yellow_cards_2023                         10168 non-null  float64
 52  last_season_2022                          10168 non-null  int32
 53  last_season_2023                          10168 non-null  int32
 54  current_club_domestic_competition_id_GB1  10168 non-null  int32
```

```
 55  current_club_name_Arsenal FC              10168 non-null  int32
 56  current_club_name_Bayern Munich           10168 non-null  int32
 57  current_club_name_Chelsea FC              10168 non-null  int32
 58  current_club_name_FC Barcelona            10168 non-null  int32
 59  current_club_name_Liverpool FC            10168 non-null  int32
 60  current_club_name_Manchester City         10168 non-null  int32
 61  current_club_name_Manchester United       10168 non-null  int32
 62  current_club_name_Paris Saint-Germain     10168 non-null  int32
 63  current_club_name_Real Madrid             10168 non-null  int32
 64  current_club_name_Tottenham Hotspur       10168 non-null  int32
dtypes: float64(52), int32(13)
memory usage: 4.5 MB
```

In [336…
```
df8_dummies_all_fs_rb_scaled.describe()
```

Out[336…

	current_club_id	market_value_in_eur	remaining_contract_days	games_total	g
count	10168.000000	10168.000000	10168.000000	10168.000000	101
mean	1.599635	1.233607	0.070395	0.226430	
std	5.063443	3.923448	0.590581	0.649751	
min	-0.407807	-0.316000	-1.042466	-0.405405	
25%	-0.255399	-0.200000	-0.500000	-0.337838	
50%	0.000000	0.000000	0.000000	0.000000	
75%	0.744601	0.800000	0.500000	0.662162	
max	34.340947	71.680000	3.502740	2.500000	

In [337…
```
df8_dummies_all.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 10168 entries, 72 to 30129
Columns: 374 entries, current_club_id to current_club_name_Ümraniyespor
dtypes: float64(2), int32(356), int64(16)
memory usage: 15.5 MB
```

In [339…
```
df8_dummies_all.columns
```

Out[339…
```
Index(['current_club_id', 'height_in_cm', 'market_value_in_eur', 'age',
       'remaining_contract_days', 'games_total', 'goals_total',
       'assists_total', 'minutes_played_total', 'goals_for_total',
       ...
       'current_club_name_Villarreal CF', 'current_club_name_Vitesse Arnhem',
       'current_club_name_Vitória Guimarães SC', 'current_club_name_Volos NPS',
       'current_club_name_Vorskla Poltava',
       'current_club_name_West Ham United',
       'current_club_name_Wolverhampton Wanderers',
       'current_club_name_Zenit St. Petersburg',
       'current_club_name_Zorya Lugansk', 'current_club_name_Ümraniyespor'],
      dtype='object', length=374)
```

Preprocessing: Median Datasets

Loading data

In [6]:
```
# Reading in the data and assign it to 'df' variable/object
median_df = pd.read_csv("Merged_Current_Players_Median_Data_4_Pre_Processing.csv
```

Confirming load and viewing general information on dataset

In [7]:
```
median_df.shape
```

Out[7]:
```
(10169, 79)
```

In [8]:
```
median_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10169 entries, 0 to 10168
Data columns (total 79 columns):
 #   Column                                Non-Null Count  Dtype
---  ------                                --------------  -----
 0   player_id                             10169 non-null  int64
 1   first_name                            9568 non-null   object
 2   last_name                             10169 non-null  object
 3   name                                  10169 non-null  object
 4   last_season                           10169 non-null  int64
 5   current_club_id                       10169 non-null  int64
 6   player_code                           10169 non-null  object
 7   country_of_birth                      8843 non-null   object
 8   city_of_birth                         9319 non-null   object
 9   country_of_citizenship                9627 non-null   object
 10  date_of_birth                         10169 non-null  object
 11  sub_position                          10169 non-null  object
 12  position                              10169 non-null  object
 13  foot                                  9574 non-null   object
 14  height_in_cm                          9518 non-null   float64
 15  market_value_in_eur                   10169 non-null  float64
 16  highest_market_value_in_eur           9747 non-null   float64
 17  contract_expiration_date              8945 non-null   object
 18  image_url                             10169 non-null  object
 19  url                                   10169 non-null  object
 20  current_club_domestic_competition_id  10169 non-null  object
 21  current_club_name                     10169 non-null  object
 22  age                                   10169 non-null  int64
 23  remaining_contract_days               8945 non-null   float64
 24  age_group                             10169 non-null  object
 25  games_total                           10169 non-null  int64
 26  goals_total                           10169 non-null  int64
 27  assists_total                         10169 non-null  int64
 28  minutes_played_total                  10169 non-null  int64
 29  goals_for_total                       10169 non-null  int64
 30  goals_against_total                   10169 non-null  int64
 31  clean_sheet_total                     10169 non-null  int64
 32  yellow_cards_total                    10169 non-null  int64
 33  red_cards_total                       10169 non-null  int64
 34  games_2019                            10169 non-null  float64
 35  goals_2019                            10169 non-null  float64
 36  assists_2019                          10169 non-null  float64
 37  minutes_played_2019                   10169 non-null  float64
 38  goals_for_2019                        10169 non-null  float64
 39  goals_against_2019                    10169 non-null  float64
 40  clean_sheet_2019                      10169 non-null  float64
 41  yellow_cards_2019                     10169 non-null  float64
 42  red_cards_2019                        10169 non-null  float64
 43  games_2020                            10169 non-null  float64
 44  goals_2020                            10169 non-null  float64
 45  assists_2020                          10169 non-null  float64
 46  minutes_played_2020                   10169 non-null  float64
 47  goals_for_2020                        10169 non-null  float64
 48  goals_against_2020                    10169 non-null  float64
 49  clean_sheet_2020                      10169 non-null  float64
 50  yellow_cards_2020                     10169 non-null  float64
 51  red_cards_2020                        10169 non-null  float64
 52  games_2021                            10169 non-null  float64
 53  goals_2021                            10169 non-null  float64
 54  assists_2021                          10169 non-null  float64
```

```
 55  minutes_played_2021                  10169 non-null  float64
 56  goals_for_2021                       10169 non-null  float64
 57  goals_against_2021                   10169 non-null  float64
 58  clean_sheet_2021                     10169 non-null  float64
 59  yellow_cards_2021                    10169 non-null  float64
 60  red_cards_2021                       10169 non-null  float64
 61  games_2022                           10169 non-null  float64
 62  goals_2022                           10169 non-null  float64
 63  assists_2022                         10169 non-null  float64
 64  minutes_played_2022                  10169 non-null  float64
 65  goals_for_2022                       10169 non-null  float64
 66  goals_against_2022                   10169 non-null  float64
 67  clean_sheet_2022                     10169 non-null  float64
 68  yellow_cards_2022                    10169 non-null  float64
 69  red_cards_2022                       10169 non-null  float64
 70  games_2023                           10169 non-null  float64
 71  goals_2023                           10169 non-null  float64
 72  assists_2023                         10169 non-null  float64
 73  minutes_played_2023                  10169 non-null  float64
 74  goals_for_2023                       10169 non-null  float64
 75  goals_against_2023                   10169 non-null  float64
 76  clean_sheet_2023                     10169 non-null  float64
 77  yellow_cards_2023                    10169 non-null  float64
 78  red_cards_2023                       10169 non-null  float64
dtypes: float64(49), int64(13), object(17)
memory usage: 6.1+ MB
```

In [9]:
```
pd.set_option('display.max_row', None)
pd.set_option('display.max_columns', None)
median_df.head(50)
```

Out[9]:

	player_id	first_name	last_name	name	last_season	current_club_id	player
0	18922	Karim	Benzema	Karim Benzema	2022	418	be
1	22860	Jesper	Hansen	Jesper Hansen	2023	678	j h
2	30321	Óscar	Trejo	Óscar Trejo	2023	367	osca
3	33925	Jessy	Moulin	Jessy Moulin	2022	1095	jessy-m
4	35099	Steven	Fletcher	Steven Fletcher	2022	1519	s fl
5	38780	Vítor	Gomes	Vítor Gomes	2023	2425	vitor-g
6	40204	Joe	Hart	Joe Hart	2023	371	jo
7	42373	Diego	Alves	Diego Alves	2022	940	diego
8	43250	Jan	Vertonghen	Jan Vertonghen	2023	58	verto
9	43858	Adam	Legzdins	Adam Legzdins	2023	511	le
10	44062	Antonio	Adán	Antonio Adán	2023	336	an
11	45314	Federico	Fazio	Federico Fazio	2023	380	fed
12	45320	Ángel	Di María	Ángel Di María	2023	294	ang
13	45389	Samuel	Di Carmine	Samuel Di Carmine	2022	2239	samu ca
14	45403	André	Ayew	André Ayew	2022	703	andre
15	46106	Adam	Le Fondre	Adam Le Fondre	2023	903	ad
16	51152	Aleksandar	Mitrović	Aleksandar Mitrović	2022	931	aleks m
17	54846	Fabian	Holland	Fabian Holland	2023	105	f h
18	55769	Danilo	D'Ambrosio	Danilo D'Ambrosio	2023	2919	d dam
19	56809	Alexandre	Oukidja	Alexandre Oukidja	2023	347	alex d
20	57051	Sebastian	Rudy	Sebastian Rudy	2022	533	seb

	player_id	first_name	last_name	name	last_season	current_club_id	player
21	58418	Vadym	Milko	Vadym Milko	2023	48332	v
22	59016	David	Alaba	David Alaba	2023	418	david
23	59145	Gernot	Trauner	Gernot Trauner	2023	234	g t
24	59866	Victor	Moses	Victor Moses	2023	232	
25	60164	Anastasios	Avlonitis	Anastasios Avlonitis	2023	3385	anas av
26	60558	Maxime	Le Marchand	Maxime Le Marchand	2022	667	maxi mar
27	63186	Roberto	Soriano	Roberto Soriano	2022	1025	ro s
28	64598	Bernardo	Espinosa	Bernardo Espinosa	2023	12321	ber es
29	65278	NaN	Pedro	Pedro	2023	398	
30	67089	Juan	Cala	Juan Cala	2022	2687	jua
31	69636	Mathias	Gehrt	Mathias Gehrt	2023	1894	ma
32	70359	David	Simão	David Simão	2023	8024	david-
33	71701	Oliver	Lund	Oliver Lund	2022	678	olive
34	74683	Nemanja	Matic	Nemanja Matic	2023	273	ner
35	77383	Eiji	Kawashima	Eiji Kawashima	2022	667	kawa
36	78570	Anthony	Moris	Anthony Moris	2023	3948	an
37	79620	Ali	Crawford	Ali Crawford	2023	2578	ali-cra
38	81349	Antonio	Jakolis	Antonio Jakolis	2023	1124	an
39	81789	Maya	Yoshida	Maya Yoshida	2022	33	y
40	85177	Nathaniel	Clyne	Nathaniel Clyne	2023	873	natl

	player_id	first_name	last_name	name	last_season	current_club_id	player
41	86097	Roman	Akbashev	Roman Akbashev	2023	1083	r akb
42	86202	Antonio	Rüdiger	Antonio Rüdiger	2023	418	an r
43	88103	James	Rodríguez	James Rodríguez	2022	683	j rod
44	90024	Alfred	Finnbogason	Alfred Finnbogason	2023	1245	finnbo
45	90478	Lukas	Van Eenoo	Lukas Van Eenoo	2023	968	luka
46	92164	Mats	Rits	Mats Rits	2023	58	ma
47	95707	Volodymyr	Tanchyk	Volodymyr Tanchyk	2023	60551	volod ta
48	95755	Viktor	Fischer	Viktor Fischer	2022	1096	
49	99227	Andrea	Bertolacci	Andrea Bertolacci	2022	3205	a ber

In [10]:
```
median_df.nunique()
```

Out[10]:

player_id	10169
first_name	3421
last_name	8445
name	10072
last_season	2
current_club_id	274
player_code	10067
country_of_birth	152
city_of_birth	4000
country_of_citizenship	144
date_of_birth	6751
sub_position	13
position	4
foot	3
height_in_cm	46
market_value_in_eur	115
highest_market_value_in_eur	147
contract_expiration_date	48
image_url	9066
url	10169
current_club_domestic_competition_id	14
current_club_name	274
age	28
remaining_contract_days	48
age_group	5
games_total	205
goals_total	91
assists_total	63
minutes_played_total	5227
goals_for_total	410
goals_against_total	256
clean_sheet_total	92
yellow_cards_total	55
red_cards_total	6
games_2019	57
goals_2019	35
assists_2019	24
minutes_played_2019	2203
goals_for_2019	128
goals_against_2019	83
clean_sheet_2019	27
yellow_cards_2019	21
red_cards_2019	3
games_2020	56
goals_2020	38
assists_2020	22
minutes_played_2020	2372
goals_for_2020	125
goals_against_2020	86
clean_sheet_2020	31
yellow_cards_2020	18
red_cards_2020	3
games_2021	55
goals_2021	35
assists_2021	23
minutes_played_2021	2610
goals_for_2021	130
goals_against_2021	84
clean_sheet_2021	27
yellow_cards_2021	19

```
red_cards_2021                    3
games_2022                       58
goals_2022                       33
assists_2022                     22
minutes_played_2022            2839
goals_for_2022                  126
goals_against_2022               82
clean_sheet_2022                 29
yellow_cards_2022                20
red_cards_2022                    4
games_2023                       21
goals_2023                       15
assists_2023                     10
minutes_played_2023            1118
goals_for_2023                   51
goals_against_2023               36
clean_sheet_2023                 11
yellow_cards_2023                 8
red_cards_2023                    3
dtype: int64
```

Feature Engineering: Feature Selection

Removing Unrequired Features

In [11]:
```
median_df.columns
```

Out[11]:
```
Index(['player_id', 'first_name', 'last_name', 'name', 'last_season',
       'current_club_id', 'player_code', 'country_of_birth', 'city_of_birth',
       'country_of_citizenship', 'date_of_birth', 'sub_position', 'position',
       'foot', 'height_in_cm', 'market_value_in_eur',
       'highest_market_value_in_eur', 'contract_expiration_date', 'image_url',
       'url', 'current_club_domestic_competition_id', 'current_club_name',
       'age', 'remaining_contract_days', 'age_group', 'games_total',
       'goals_total', 'assists_total', 'minutes_played_total',
       'goals_for_total', 'goals_against_total', 'clean_sheet_total',
       'yellow_cards_total', 'red_cards_total', 'games_2019', 'goals_2019',
       'assists_2019', 'minutes_played_2019', 'goals_for_2019',
       'goals_against_2019', 'clean_sheet_2019', 'yellow_cards_2019',
       'red_cards_2019', 'games_2020', 'goals_2020', 'assists_2020',
       'minutes_played_2020', 'goals_for_2020', 'goals_against_2020',
       'clean_sheet_2020', 'yellow_cards_2020', 'red_cards_2020', 'games_2021',
       'goals_2021', 'assists_2021', 'minutes_played_2021', 'goals_for_2021',
       'goals_against_2021', 'clean_sheet_2021', 'yellow_cards_2021',
       'red_cards_2021', 'games_2022', 'goals_2022', 'assists_2022',
       'minutes_played_2022', 'goals_for_2022', 'goals_against_2022',
       'clean_sheet_2022', 'yellow_cards_2022', 'red_cards_2022', 'games_2023',
       'goals_2023', 'assists_2023', 'minutes_played_2023', 'goals_for_2023',
       'goals_against_2023', 'clean_sheet_2023', 'yellow_cards_2023',
       'red_cards_2023'],
      dtype='object')
```

Removing features that will not aid in evaluating player market values such as unique identifiers, names and images, aswell as demographical features that may introduce bias. 'highest_market_value_in_eur' will also be removed as it derived from 'market_value_in_eur', our target label.

In [92]:
```
median_df2 = median_df.drop(['player_id', 'first_name', 'last_name', 'name','las
```

In [93]:
```
median_df2.shape
```

Out[93]: (10169, 64)

Preprocessing: Handling Missing Values

Identifying Missing Values

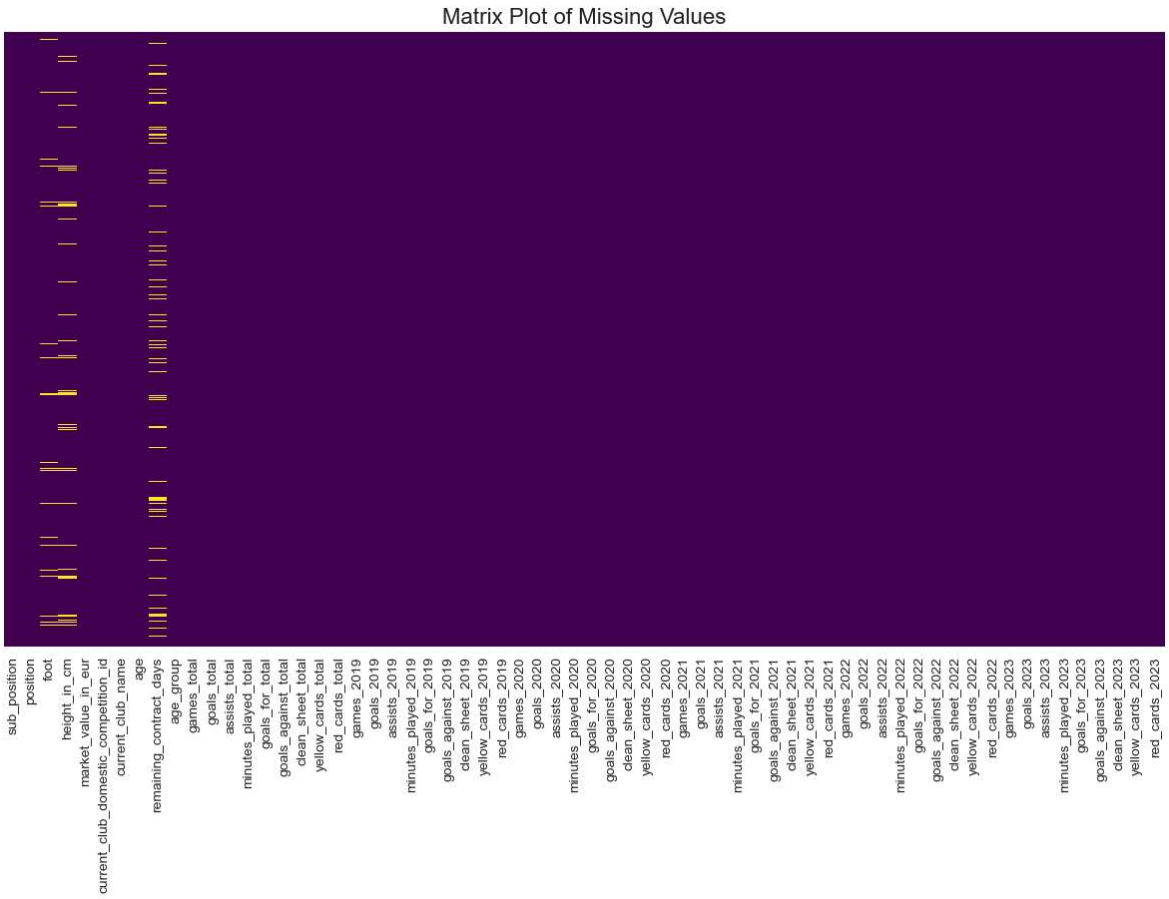
In [94]:
```
median_df2.isnull().sum()
```

Out[94]:

sub_position	0
position	0
foot	595
height_in_cm	651
market_value_in_eur	0
current_club_domestic_competition_id	0
current_club_name	0
age	0
remaining_contract_days	1224
age_group	0
games_total	0
goals_total	0
assists_total	0
minutes_played_total	0
goals_for_total	0
goals_against_total	0
clean_sheet_total	0
yellow_cards_total	0
red_cards_total	0
games_2019	0
goals_2019	0
assists_2019	0
minutes_played_2019	0
goals_for_2019	0
goals_against_2019	0
clean_sheet_2019	0
yellow_cards_2019	0
red_cards_2019	0
games_2020	0
goals_2020	0
assists_2020	0
minutes_played_2020	0
goals_for_2020	0
goals_against_2020	0
clean_sheet_2020	0
yellow_cards_2020	0
red_cards_2020	0
games_2021	0
goals_2021	0
assists_2021	0
minutes_played_2021	0
goals_for_2021	0
goals_against_2021	0
clean_sheet_2021	0
yellow_cards_2021	0
red_cards_2021	0
games_2022	0
goals_2022	0
assists_2022	0
minutes_played_2022	0
goals_for_2022	0
goals_against_2022	0
clean_sheet_2022	0
yellow_cards_2022	0
red_cards_2022	0
games_2023	0
goals_2023	0
assists_2023	0
minutes_played_2023	0
goals_for_2023	0

```
goals_against_2023                    0
clean_sheet_2023                      0
yellow_cards_2023                     0
red_cards_2023                        0
dtype: int64
```

In [95]:
```
plt.figure(figsize=(15, 8))
sns.heatmap(median_df2.isnull(), yticklabels=False,cbar=False, cmap='viridis')

plt.title("Matrix Plot of Missing Values", fontsize=16);
```



Addressing the 'height_in_cm' Missing Values

In [96]:
```
median_df2['height_in_cm'].describe()
```

Out[96]:
```
count    9518.000000
mean      182.666527
std         6.928958
min       160.000000
25%       178.000000
50%       183.000000
75%       188.000000
max       206.000000
Name: height_in_cm, dtype: float64
```

In [97]:
```
median_df2.groupby(['position'])['height_in_cm'].median().reset_index()
```

Out[97]:

	position	height_in_cm
0	Attack	180.0
1	Defender	185.0
2	Goalkeeper	190.0
3	Midfield	180.0

In [98]:
```
# Calculating the median height values based on position and sub position
median_height_values = median_df2.groupby(['position', 'sub_position'])['height_

# Displaying the mean values
print(median_height_values)
```

```
      position        sub_position  height_in_cm
0       Attack      Centre-Forward         185.0
1       Attack         Left Winger         177.0
2       Attack        Right Winger         177.0
3       Attack      Second Striker         179.0
4     Defender         Centre-Back         188.0
5     Defender           Left-Back         180.0
6     Defender          Right-Back         180.0
7   Goalkeeper          Goalkeeper         190.0
8     Midfield  Attacking Midfield         178.0
9     Midfield    Central Midfield         180.0
10    Midfield  Defensive Midfield         183.0
11    Midfield       Left Midfield         179.0
12    Midfield      Right Midfield         177.0
```

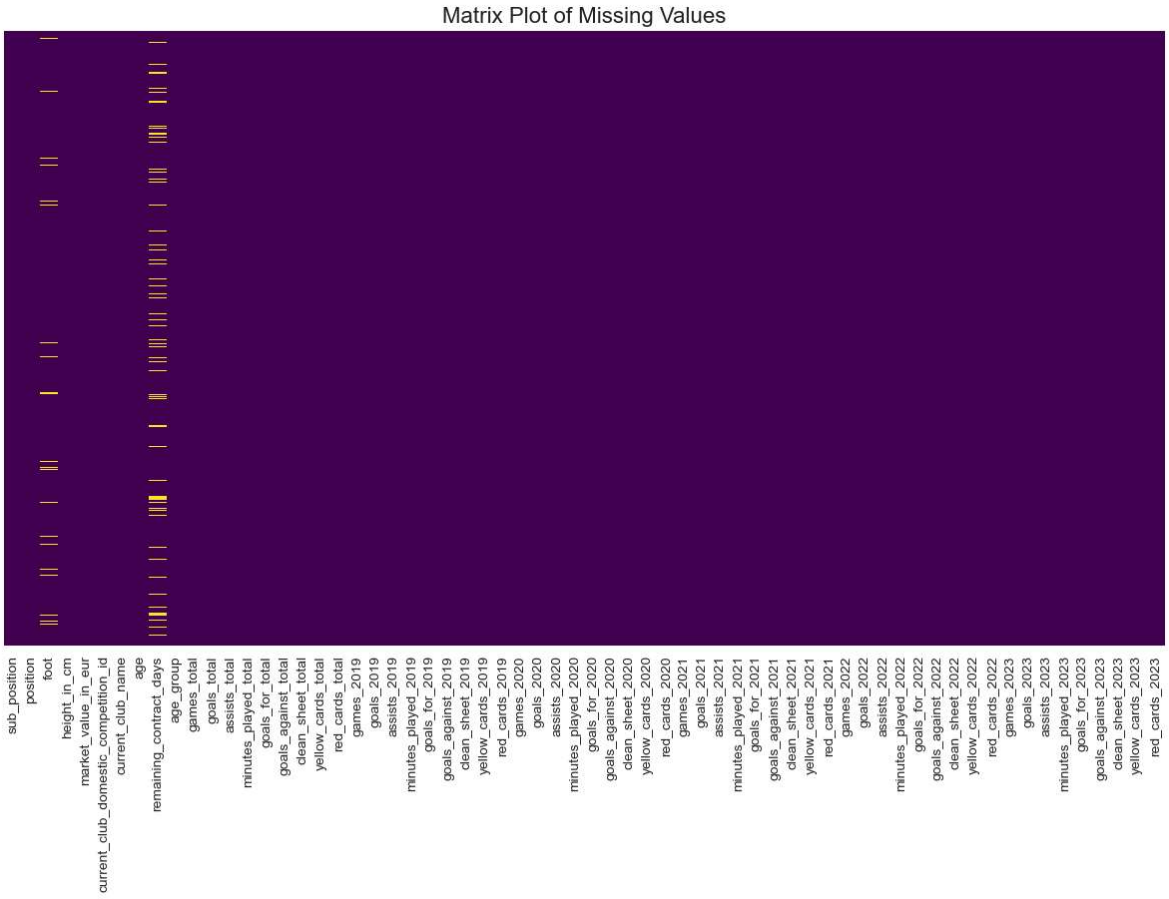
In [99]:
```
# Writing a function of conditional statements for imputing the median height va
def impute_height_median(cols):
    height_in_cm = cols[0]
    position = cols[1]
    sub_position = cols[2]

    if pd.isnull(height_in_cm):

        if position == 'Attack':
            if sub_position == 'Centre-Forward':
                return 185.0
            elif sub_position == 'Left Winger':
                return 177.0
            elif sub_position == 'Right Winger':
                return 177.0
            elif sub_position == 'Second Striker':
                return 179.0
            else:
                return 180.0

        elif position == 'Defender':
            if sub_position == 'Centre-Back':
                return 188.0
            elif sub_position == 'Left-Back':
                return 180.0
            elif sub_position == 'Right-Back':
                return 180.0
            else:
                return 185.0
```

```
        elif position == 'Goalkeeper':
            if sub_position == 'Goalkeeper':
                return 190.0
            else:
                return 190.0

        elif position == 'Midfield':
            if sub_position == 'Attacking Midfield':
                return 178.0
            elif sub_position == 'Central Midfield':
                return 180.0
            elif sub_position == 'Defensive Midfield':
                return 183.0
            elif sub_position == 'Left Midfield':
                return 179.0
            elif sub_position == 'Right Midfield':
                return 177.0
            else:
                return 180.0

        else:
            return 183.000000

    else:
        return height_in_cm
```

In [100…
```
median_df3 = median_df2.copy()
```

In [101…
```
# Applying the impute_height function to the dataframe
median_df3['height_in_cm'] = median_df2[['height_in_cm', 'position', 'sub_positi
```

In [102…
```
plt.figure(figsize=(15, 8))
sns.heatmap(median_df3.isnull(), yticklabels=False,cbar=False, cmap='viridis')

plt.title("Matrix Plot of Missing Values", fontsize=16);
```



Addressing the 'foot' Missing Values

In [103…
```
median_df3['foot'].describe()
```

Out[103…
```
count      9574
unique        3
top       right
freq       6737
Name: foot, dtype: object
```

In [104…
```
median_df3['foot'].unique()
```

Out[104…
```
array(['right', 'left', nan, 'both'], dtype=object)
```

Given that its a categorical variable, we will use the mode for imputation.

In [105…
```
# Calculating the mode for foot values based on position and sub_position
mode_foot_values = median_df3.groupby(['position', 'sub_position'])['foot'].agg(

# Displaying the mode values
print(mode_foot_values)
```

```
      position         sub_position   foot
0       Attack      Centre-Forward  right
1       Attack         Left Winger  right
2       Attack        Right Winger  right
3       Attack      Second Striker  right
4     Defender         Centre-Back  right
5     Defender           Left-Back   left
6     Defender          Right-Back  right
7   Goalkeeper          Goalkeeper  right
8     Midfield  Attacking Midfield  right
9     Midfield    Central Midfield  right
10    Midfield  Defensive Midfield  right
11    Midfield       Left Midfield   left
12    Midfield      Right Midfield  right
```

In [106…

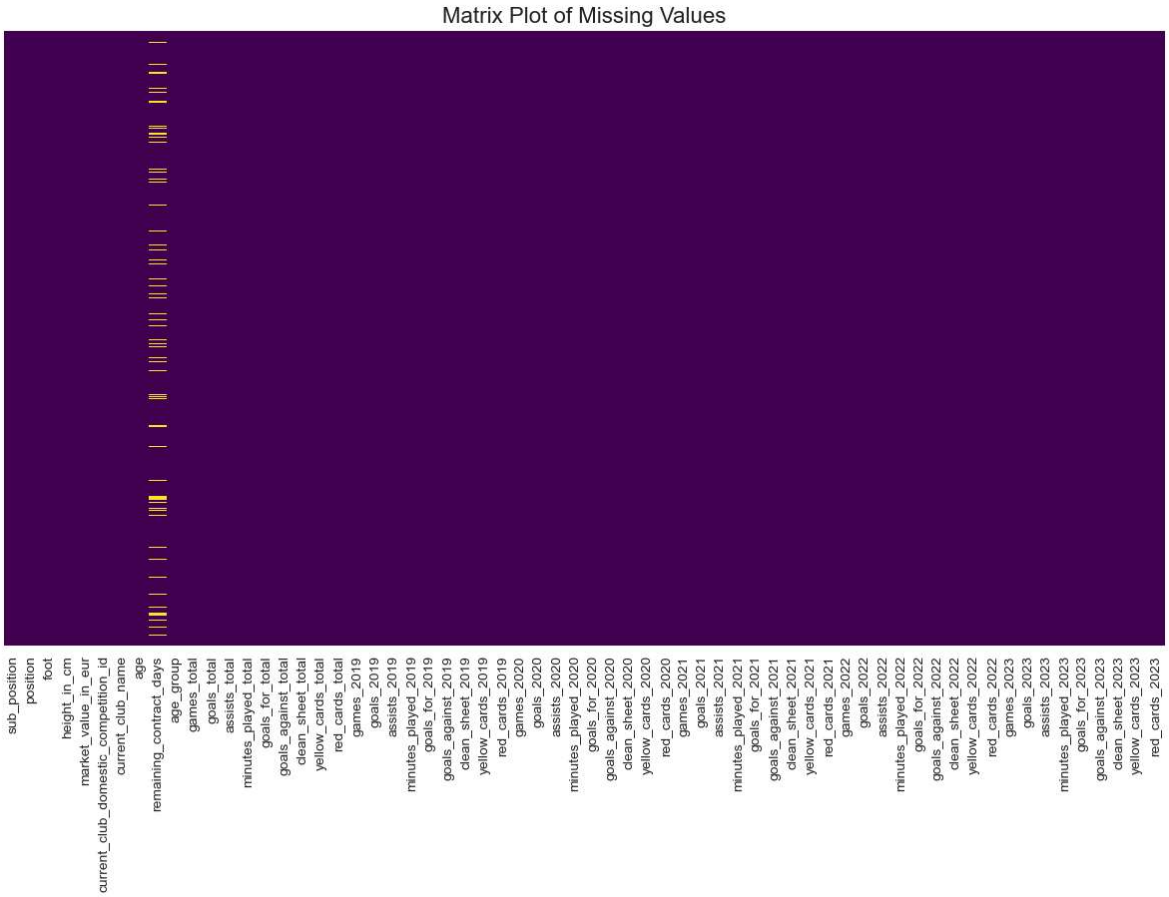
```python
# Writing a function of conditional statements for imputing the mode for foot ba
def impute_foot(cols):
    foot = cols[0]
    position = cols[1]
    sub_position = cols[2]

    if pd.isnull(foot):
        if position == 'Attack':
            return 'right'

        elif position == 'Defender':
            if sub_position == 'Left-Back':
                return 'left'
            else:
                return 'right'

        elif position == 'Goalkeeper':
            return 'right'

        elif position == 'Midfield':
            if sub_position == 'Left Midfield':
                return 'left'
            else:
                return 'right'

        else:
            return 'right'

    else:
        return foot
```

In [107…

```python
# Applying the impute_height function to the dataframe
median_df3['foot'] = median_df3[['foot', 'position', 'sub_position']].apply(impu
```

In [108…

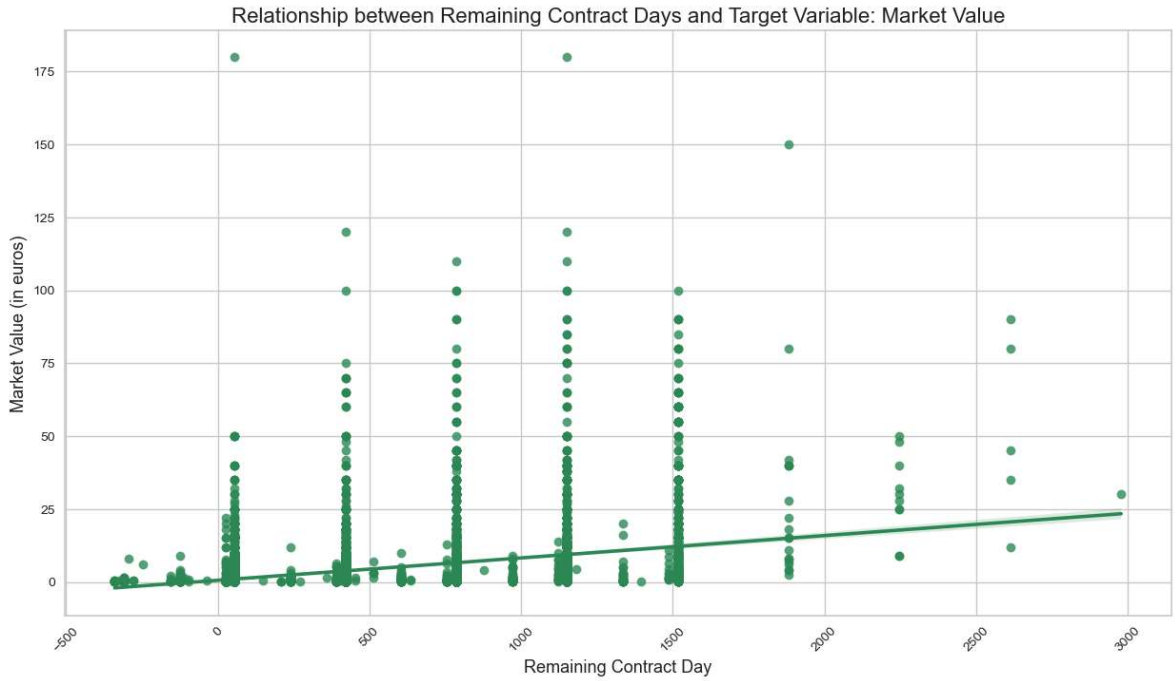
```python
plt.figure(figsize=(15, 8))
sns.heatmap(median_df3.isnull(), yticklabels=False,cbar=False, cmap='viridis')

plt.title("Matrix Plot of Missing Values", fontsize=16);
```



Addressing the 'remaining_contract_days' Missing Values

In [109…

```
plt.figure(figsize=(15, 8))
sns.regplot(data = median_df3, x = median_df3['remaining_contract_days'], y
plt.xlabel('Remaining Contract Day', fontsize=13)
plt.ylabel("Market Value (in euros)", fontsize=13)
plt.xticks(rotation = 45)
plt.title( f"Relationship between Remaining Contract Days and Target Variabl
plt.grid(True)
plt.show()
```



In [110…
```
correlation = median_df3['remaining_contract_days'].corr(median_df3['market_valu
print(f"Correlation between remaining_contract_days and market_value_in_eur: {co
```

```
Correlation between remaining_contract_days and market_value_in_eur: 0.3429730030
7003026
```

In [111…
```
plt.figure(figsize=(15, 8))
sns.boxplot(y = median_df3['remaining_contract_days'], color = "#483D8B")
plt.xlabel('Remaining Contract Day', fontsize=13)
plt.title("Remaining Contract Days Boxplot of Variance and Outliers", fontsize=1
plt.grid(True)
plt.show()
```