In [2]:
```
import requests
from bs4 import BeautifulSoup
from datetime import datetime, timedelta
import time
import pandas as pd
import numpy as np
import random
from tqdm import tqdm
import torch
import torch.nn as nn
import torch.nn.functional as F
from torch.utils.data import TensorDataset, DataLoader
from sklearn.model_selection import train_test_split, KFold
import matplotlib.pyplot as plt
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score
from sklearn.ensemble import RandomForestRegressor
from sklearn.metrics import mean_squared_error
from sklearn.preprocessing import OneHotEncoder, StandardScaler
```

Section 1: Data Scraping & Wrangling Data

In [67]:
```
def daterange(start_date, end_date):
    for n in range(int((end_date - start_date).days) + 1):
        yield start_date + timedelta(days=n)

team_name_mapping = {
    "Cleveland": "CLE",
    "Charlotte": "CHO",
    "LA Lakers": "LAL",
    "New Orleans": "NOP",
    "Brooklyn": "BRK",
    "Oklahoma City": "OKC",
    "Milwaukee": "MIL",
    "Phoenix": "PHO",
    "New York": "NYK",
    "Atlanta": "ATL",
    "Boston": "BOS",
    "Chicago": "CHI",
    "Dallas": "DAL",
    "Denver": "DEN",
    "Detroit": "DET",
    "Golden State": "GSW",
    "Houston": "HOU",
    "Indiana": "IND",
    "LA Clippers": "LAC",
    "Memphis": "MEM",
    "Miami": "MIA",
    "Minnesota": "MIN",
    "Orlando": "ORL",
    "Philadelphia": "PHI",
    "Portland": "POR",
    "Sacramento": "SAC",
    "San Antonio": "SAS",
    "Toronto": "TOR",
    "Utah": "UTA",
```

```
    "Washington": "WAS",
}

def rate_limit(requests, per_minute, last_request_time):
    if len(requests) >= per_minute:
        time_since_oldest_request = datetime.now() - requests[0]
        if time_since_oldest_request < timedelta(minutes=1):
            sleep_time = (timedelta(minutes=1) - time_since_oldest_request).total_secc
            print(f"Rate limit reached, sleeping for {sleep_time} seconds.")
            time.sleep(sleep_time)
        requests.pop(0)
    requests.append(datetime.now())

request_times = []

def scrape_basic_box_score_stats(url, team_abbr):
    headers = {
        'User-Agent': 'Mozilla/5.0 (Macintosh; Intel Mac OS X 10.15; rv:86.0) Gecko/20
    }
    response = requests.get(url, headers=headers)
    rate_limit(request_times, 9, datetime.now())
    if response.status_code != 200:
        print(f"Failed to retrieve data from {url}")
        return {}

    soup = BeautifulSoup(response.content, 'html.parser')
    table_id = f'box-{team_abbr}-game-basic'
    table = soup.find('table', id=table_id)

    desired_stats = {
        'FGA': None,
        'FG_pct': None,
        'FTA': None,
        'FT_pct': None,
        'TRB': None,
        'fg3a': None,
        'fg3_pct': None,
        'TOV': None,
        'stl': None,
        'blk': None,
        'ast': None
    }

    if table:
        totals_row = table.find('tfoot').find('tr')
        if totals_row:
            for stat in desired_stats.keys():
                data_cell = totals_row.find('td', {'data-stat': stat.lower()})
                if data_cell:
                    desired_stats[stat] = data_cell.text.strip()

    return desired_stats

def scrape_general_game_info(date):
    headers = {
        'User-Agent': 'Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (K
    }
    url = f"https://www.basketball-reference.com/boxscores/?month={date.month:02d}&day
    rate_limit(request_times, 9, datetime.now())
    response = requests.get(url, headers=headers)
```

```
    if response.status_code != 200:
        print(f"Request failed for {url} with status code {response.status_code}")
        return []

    soup = BeautifulSoup(response.content, 'html.parser')
    games_info = []

    game_summaries = soup.find_all('div', class_='game_summary expanded nohover')
    for game_summary in game_summaries:
        teams = game_summary.find_all('tr', class_=['winner', 'loser'])
        box_score_link_tag = game_summary.find('p', class_='links').find('a', text='Bo
        if len(teams) == 2 and box_score_link_tag:
            box_score_link = "https://www.basketball-reference.com" + box_score_link_t
            team1, team1_score = teams[0].find('a').text.strip(), teams[0].find('td',
            team2, team2_score = teams[1].find('a').text.strip(), teams[1].find('td',
            game_info = {
                'date': date.strftime('%Y-%m-%d'),
                'team1': team1,
                'team1_score': team1_score,
                'team2': team2,
                'team2_score': team2_score,
                'box_score_link': box_score_link
            }

            game_info['team1_stats'] = scrape_basic_box_score_stats(box_score_link, te
            game_info['team2_stats'] = scrape_basic_box_score_stats(box_score_link, te
            games_info.append(game_info)
    return games_info
```

In [ ]:

```
#date range
start_date = datetime(2023, 11, 1)
end_date = datetime(2024, 4, 5)
total_days = (end_date - start_date).days + 1

#collecting all games data
all_games_data = []
for single_date in tqdm(daterange(start_date, end_date), total=total_days, desc = "Scr
    games_info = scrape_general_game_info(single_date)
    all_games_data.extend(games_info)

expanded_games_data = []

for game in all_games_data:
    #extracting basic game info
    game_info = {
        'date': game['date'],
        'team1': game['team1'],
        'team1_score': game['team1_score'],
        'team2': game['team2'],
        'team2_score': game['team2_score'],
    }

    #extracting team1 stats and prefix with 'team1_'
    team1_stats = {f'team1_{k}': v for k, v in game['team1_stats'].items()}
    game_info.update(team1_stats)

    #extracting team2 stats and prefix with 'team2_'
    team2_stats = {f'team2_{k}': v for k, v in game['team2_stats'].items()}
    game_info.update(team2_stats)
```

```
    #adding the expanded game info to the new list
    expanded_games_data.append(game_info)

#converting to a DataFrame for analysis
df_games = pd.DataFrame(expanded_games_data)

print("Dataset with General Game Info and Basic Box Score Stats:")
print(df_games)
```

In [ ]:
```
#converted scraped data to csv to save it... so i don't spend another 5 hours data scr

df_games.to_csv('br.csv', index = False)
```

In [68]:
```
br_df = pd.read_csv('br.csv')
print(br_df)
```

```
           date        team1  team1_score         team2  team2_score  \
0     11/1/2023   Washington          121       Atlanta          130   
1     11/1/2023      Indiana          104        Boston          155   
2     11/1/2023      Chicago          105        Dallas          114   
3     11/1/2023     Portland          110       Detroit          101   
4     11/1/2023   Sacramento          101  Golden State          102   
...         ...          ...          ...           ...          ...   
1098   4/5/2024      Detroit           90       Memphis          108   
1099   4/5/2024      Toronto          117     Milwaukee          111   
1100   4/5/2024  San Antonio          111   New Orleans          109   
1101   4/5/2024    Minnesota           87       Phoenix           97   
1102   4/5/2024     Portland          108    Washington          102   

      team1_FGA  team1_FG_pct  team1_FTA  team1_FT_pct  team1_TRB  ...  \
0           101         0.505         14         0.643         35  ...   
1           101         0.455         12         0.583         31  ...   
2            89         0.472         11         0.909         43  ...   
3            81         0.469         33         0.818         44  ...   
4            88         0.409         23         0.783         48  ...   
...         ...           ...        ...           ...        ...  ...   
1098         79         0.405         24         0.750         38  ...   
1099         79         0.456         36         0.861         47  ...   
1100         83         0.506         13         0.769         34  ...   
1101         85         0.388         14         0.786         44  ...   
1102         94         0.436         24         0.708         55  ...   

      team2_FG_pct  team2_FTA  team2_FT_pct  team2_TRB  team2_fg3a  \
0            0.500         32         0.906         57          32   
1            0.568         28         0.964         57          35   
2            0.457         28         0.714         45          48   
3            0.444         11         0.909         38          29   
4            0.481         15         0.867         36          31   
...            ...        ...           ...        ...         ...   
1098         0.467         16         0.875         49          31   
1099         0.436         21         0.810         45          42   
1100         0.512         12         1.000         41          29   
1101         0.434         29         0.759         49          26   
1102         0.432         30         0.700         45          33   

      team2_fg3_pct  team2_TOV  team2_stl  team2_blk  team2_ast  
0             0.281         20          8          3         26  
1             0.571         11          5          2         27  
2             0.417         13          7          2         23  
3             0.379         18         12          4         24  
4             0.355         17          5          6         32  
...             ...        ...        ...        ...        ...  
1098          0.323         20         13          7         24  
1099          0.286         13          8          6         21  
1100          0.310         17         11          2         28  
1101          0.346         18         12          3         29  
1102          0.152          9          9          5         24  

[1103 rows x 27 columns]
```

In [69]:
```python
unique_teams = pd.unique(br_df[['team1', 'team2']].values.ravel('K'))
#mapped each team to a unique integer
team_to_id = {team: i for i, team in enumerate(unique_teams)}
print(team_to_id)
br_df['Home_Team_ID'] = br_df['team2'].map(team_to_id) # home team is team 2
br_df['Away_Team_ID'] = br_df['team1'].map(team_to_id) # away team is team 1
```

```
#added win column
br_df['HomeWin'] = (br_df['team2_score'] > br_df['team1_score']).astype(int) #astype c

br_df['date'] = pd.to_datetime(br_df['date'])
br_df['month'] = (br_df['date'].dt.month - 11) % 12
print(br_df)
```

```
{'Washington': 0, 'Indiana': 1, 'Chicago': 2, 'Portland': 3, 'Sacramento': 4, 'Charlo
tte': 5, 'LA Clippers': 6, 'Brooklyn': 7, 'Denver': 8, 'Cleveland': 9, 'New Orleans':
10, 'Milwaukee': 11, 'Memphis': 12, 'Detroit': 13, 'Toronto': 14, 'San Antonio': 15,
'Orlando': 16, 'Dallas': 17, 'New York': 18, 'Golden State': 19, 'Boston': 20, 'Uta
h': 21, 'Atlanta': 22, 'LA Lakers': 23, 'Phoenix': 24, 'Miami': 25, 'Philadelphia': 2
6, 'Oklahoma City': 27, 'Minnesota': 28, 'Houston': 29}
            date        team1  team1_score         team2  team2_score  \
0     2023-11-01   Washington          121       Atlanta          130
1     2023-11-01      Indiana          104        Boston          155
2     2023-11-01      Chicago          105        Dallas          114
3     2023-11-01     Portland          110       Detroit          101
4     2023-11-01   Sacramento          101  Golden State          102
...          ...          ...          ...           ...          ...
1098  2024-04-05      Detroit           90       Memphis          108
1099  2024-04-05      Toronto          117     Milwaukee          111
1100  2024-04-05  San Antonio          111   New Orleans          109
1101  2024-04-05    Minnesota           87       Phoenix           97
1102  2024-04-05     Portland          108    Washington          102

      team1_FGA  team1_FG_pct  team1_FTA  team1_FT_pct  team1_TRB  ...  \
0           101         0.505         14         0.643         35  ...
1           101         0.455         12         0.583         31  ...
2            89         0.472         11         0.909         43  ...
3            81         0.469         33         0.818         44  ...
4            88         0.409         23         0.783         48  ...
...         ...           ...        ...           ...        ...  ...
1098         79         0.405         24         0.750         38  ...
1099         79         0.456         36         0.861         47  ...
1100         83         0.506         13         0.769         34  ...
1101         85         0.388         14         0.786         44  ...
1102         94         0.436         24         0.708         55  ...

      team2_fg3a  team2_fg3_pct  team2_TOV  team2_stl  team2_blk  team2_ast  \
0             32          0.281         20          8          3         26
1             35          0.571         11          5          2         27
2             48          0.417         13          7          2         23
3             29          0.379         18         12          4         24
4             31          0.355         17          5          6         32
...          ...            ...        ...        ...        ...        ...
1098          31          0.323         20         13          7         24
1099          42          0.286         13          8          6         21
1100          29          0.310         17         11          2         28
1101          26          0.346         18         12          3         29
1102          33          0.152          9          9          5         24

      Home_Team_ID  Away_Team_ID  HomeWin  month
0               22             0        1      0
1               20             1        1      0
2               17             2        1      0
3               13             3        0      0
4               19             4        1      0
...            ...           ...      ...    ...
1098            12            13        1      5
1099            11            14        0      5
1100            10            15        0      5
1101            24            28        1      5
1102             0             3        0      5

[1103 rows x 31 columns]
```

In [ ]:
```
#I saved the new 31 column version of dataframe
br_df.to_csv('br31.csv', index = False)
```

Section 2: Predicting Wins with BR31 Dataframe

In [70]:
```
home_team = torch.tensor(br_df['Home_Team_ID'], dtype=torch.long)
away_team = torch.tensor(br_df['Away_Team_ID'], dtype=torch.long)
num_classes = 30
home_teams_ohe = F.one_hot(home_team, num_classes=num_classes)
away_teams_ohe = F.one_hot(away_team, num_classes=num_classes)
date_stuff = torch.tensor(br_df['month'], dtype=torch.long)

months_ohe = F.one_hot(date_stuff, num_classes = 6)

x_ohe_tensor = torch.cat((home_teams_ohe, away_teams_ohe), dim=1)

numeric_data = br_df.drop(['date', 'month', 'Home_Team_ID', 'team1_score', 'team2_scor
scaler = StandardScaler()
x_norm = scaler.fit_transform(numeric_data)
x_norm_tensor = torch.tensor(x_norm, dtype=torch.float32)

X_almost = torch.cat((x_norm_tensor, x_ohe_tensor), dim=1)
X = torch.cat((X_almost, months_ohe), dim = 1)

print(X.shape)

y = torch.tensor(br_df['HomeWin'], dtype=torch.long)
```

```
torch.Size([1103, 88])
```

In [71]:
```
class Trainer:

    def __init__(self, model, opt_method, learning_rate, batch_size, epoch, l2):
        self.model = model
        if opt_method == "adam":
            self.optimizer = torch.optim.Adam(model.parameters(), learning_rate, weigh
        else:
            raise NotImplementedError("This optimization is not supported")

        self.epoch = epoch
        self.batch_size = batch_size

    def train(self, X_train, y_train, X_val, y_val, early_stop=True, draw_curve=True):
        train_dataset = TensorDataset(X_train, y_train)
        train_loader = DataLoader(train_dataset, batch_size=self.batch_size, shuffle=T
        val_dataset = TensorDataset(X_val, y_val)
        val_loader = DataLoader(val_dataset, batch_size=self.batch_size, shuffle=False

        train_loss_list, train_acc_list = [], []
        val_loss_list, val_acc_list = [], []
        weights = self.model.state_dict()
        lowest_val_loss = np.inf
        loss_func = nn.CrossEntropyLoss()
        for n in tqdm(range(self.epoch), leave=True):
            # enable train mode
```

```
            self.model.train()
            epoch_loss, epoch_acc = 0.0, 0.0
            for X_batch, y_batch in train_loader:
                batch_importance = y_batch.shape[0] / len(train_dataset)
                y_pred = self.model(X_batch)
                batch_loss = loss_func(y_pred, y_batch)

                self.optimizer.zero_grad()
                batch_loss.backward()
                self.optimizer.step()

                epoch_loss += batch_loss.detach().cpu().item() * batch_importance
                batch_acc = torch.sum(torch.argmax(y_pred, axis=1) == y_batch) / y_bat
                epoch_acc += batch_acc.detach().cpu().item() * batch_importance
            train_loss_list.append(epoch_loss)
            train_acc_list.append(epoch_acc)
            val_loss, val_acc = self.evaluate(val_dataset)
            val_loss_list.append(val_loss)
            val_acc_list.append(val_acc)

            if early_stop:
                if val_loss < lowest_val_loss:
                    lowest_val_loss = val_loss
                    weights = self.model.state_dict()

        if draw_curve:
            x_axis = np.arange(self.epoch)
            fig, axes = plt.subplots(1, 2, figsize=(10, 4))
            axes[0].plot(x_axis, train_loss_list, label="Train")
            axes[0].plot(x_axis, val_loss_list, label="Validation")
            axes[0].set_title("Loss")
            axes[0].legend()
            axes[1].plot(x_axis, train_acc_list, label='Train')
            axes[1].plot(x_axis, val_acc_list, label='Validation')
            axes[1].set_title("Accuracy")
            axes[1].legend()
            print(f"Validation accuracy: {np.mean(val_acc_list)}+/-{np.std(val_acc_lis

        if early_stop:
            self.model.load_state_dict(weights)

        return {
            "train_loss_list": train_loss_list,
            "train_acc_list": train_acc_list,
            "val_loss_list": val_loss_list,
            "val_acc_list": val_acc_list,
        }

    def evaluate(self, data, print_acc=False):
        # enable evaluation mode
        self.model.eval()
        loader = DataLoader(data, batch_size=self.batch_size, shuffle=True)
        loss_func = nn.CrossEntropyLoss()
        acc, loss = 0.0, 0.0
        for X_batch, y_batch in loader:
            with torch.no_grad():
                batch_importance = y_batch.shape[0] / len(data)
                y_pred = self.model(X_batch)
                batch_loss = loss_func(y_pred, y_batch)
                batch_acc = torch.sum(torch.argmax(y_pred, axis=1) == y_batch) / y_bat
```

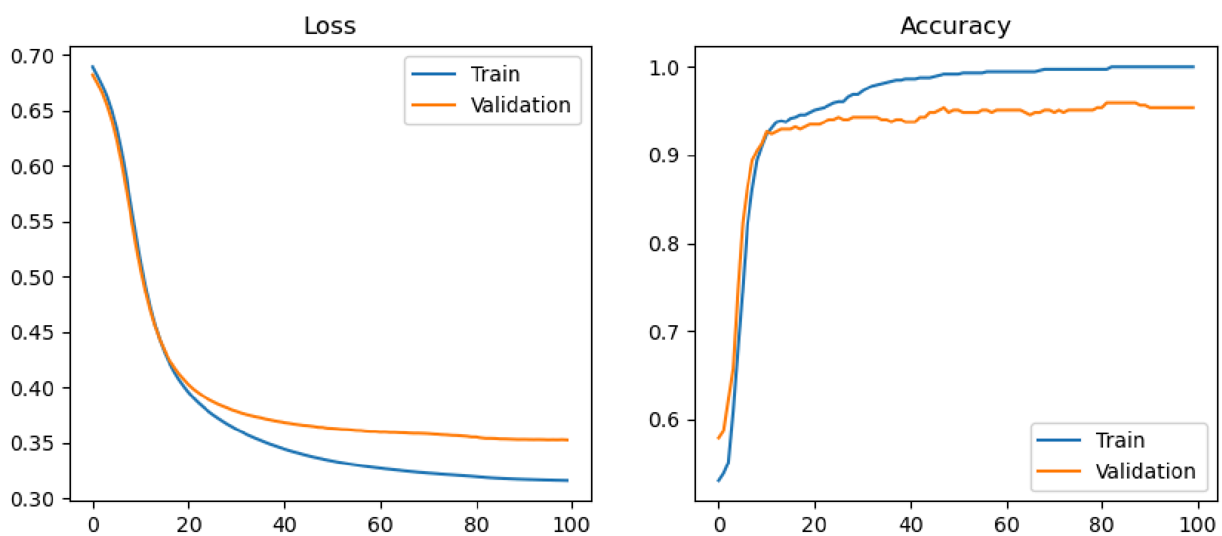
```
                acc += batch_acc.detach().cpu().item() * batch_importance
                loss += batch_loss.detach().cpu().item() * batch_importance
        if print_acc:
            print(f"Accuracy: {acc:.3f}")
        return loss, acc
```

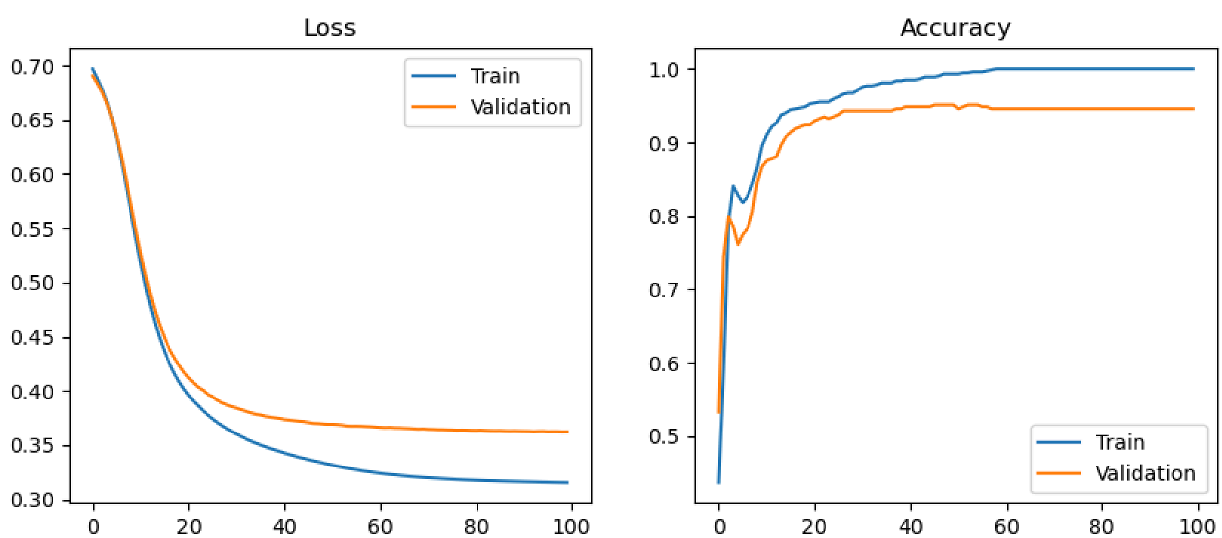
In [72]:
```
def KFoldCrossValidation(
    model_class, k,
    X, y,
    opt_method='adam', learning_rate=1e-4, batch_size=32, epoch=100, l2=0
):
    _, X_test, _, y_test = train_test_split(X, y, test_size=0.2)
    test_dataset = TensorDataset(X_test, y_test)
    kf = KFold(n_splits = k, shuffle = True)
    train_acc_list, test_acc_list = [], []
    for i, (train_index, val_index) in enumerate(kf.split(X)):
        print(f"Fold {i}:")

        X_train, X_val = X[train_index], X[val_index]
        y_train, y_val = y[train_index], y[val_index]

        model = model_class()
        # initialize a Trainer object
        trainer = Trainer(model, opt_method, learning_rate, batch_size, epoch, l2)
        # call trainer.train() here
        res = trainer.train(X_train, y_train, X_val, y_val)
        train_acc_best = res['train_acc_list'][np.argmin(res['val_loss_list'])]
        test_loss, test_acc = trainer.evaluate(test_dataset)
        if i == 1:
            torch.save(model.state_dict(), f'model_weights_fold_1.pth')
        train_acc_list.append(train_acc_best)
        test_acc_list.append(test_acc)

        print(f"Training accuracy: {train_acc_best}")
        print(f"Test accuracy: {test_acc}")

    print("Final results:")
    print(f"Training accuracy: {np.mean(train_acc_list)}+/-{np.std(train_acc_list)}")
    print(f"Test accuracy: {np.mean(test_acc_list)}+/-{np.std(test_acc_list)}")
```

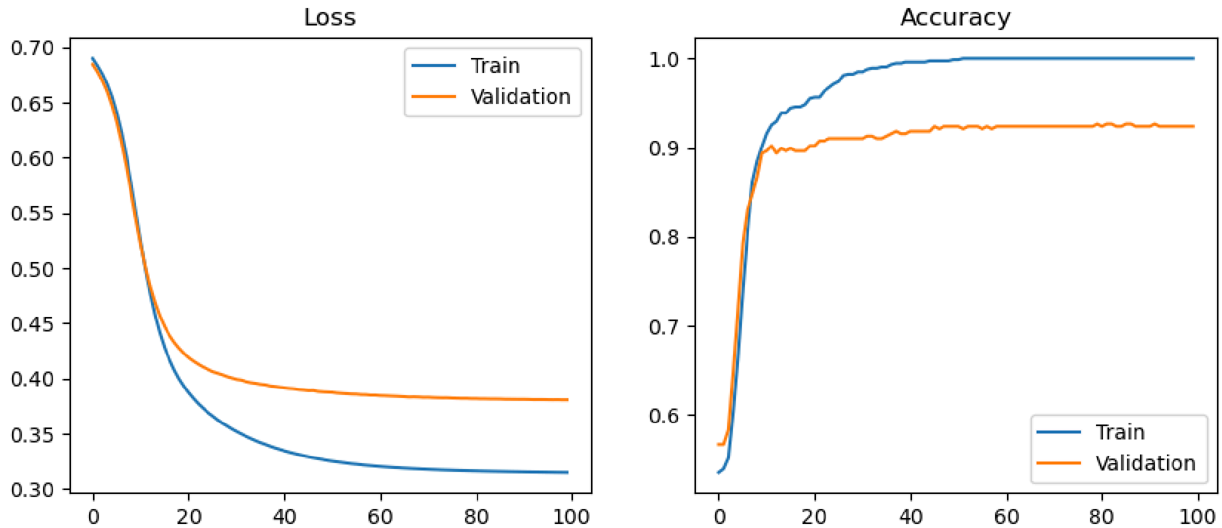
In [73]:
```
class WinPredictor(nn.Module):
    def __init__(self, ):
        super(WinPredictor, self).__init__()

        self.fc1 = nn.Linear(88, 128)

        self.fc2 = nn.Linear(128, 64)

        self.output_layer = nn.Linear(64, 2)

    def forward(self, x):

        x = F.relu(self.fc1(x))
        x = F.relu(self.fc2(x))
        # Using softmax activation function
        win_prob = F.softmax(self.output_layer(x), dim = -1)

        return win_prob
```

In [75]:
```
KFoldCrossValidation(WinPredictor, 3, X, y)
```

```
Fold 0:
100%|██████████| 100/100 [00:14<00:00,  6.96it/s]
Validation accuracy: 0.9277445652173916+/-0.07012459269549368
Training accuracy: 1.0
Test accuracy: 0.9864253393665159
Fold 1:
100%|██████████| 100/100 [00:10<00:00,  9.62it/s]
Validation accuracy: 0.9235054347826086+/-0.05982628715643639
Training accuracy: 1.0
Test accuracy: 0.9773755631835214
Fold 2:
100%|██████████| 100/100 [00:10<00:00,  9.46it/s]
Validation accuracy: 0.8991553135691287+/-0.0688608152054051
Training accuracy: 0.9999999999999996
Test accuracy: 0.9819004500613495
Final results:
Training accuracy: 0.9999999999999999+/-2.1259152388627147e-16
Test accuracy: 0.9819004508704623+/-0.0036945556557881403
```







Analysis:

1. High variance/overfitting. Model is not learning underlying relationships.

2. Given team stats for every game, model predicts wins very well (i.e., much better than random chance).

Section 2: Creating rolling average and over/under prediction

In [76]:
```
#prepared stats for team1 and team2
br_df = pd.read_csv('br31.csv')
team1_stats = br_df.filter(regex='team1').rename(columns=lambda x: x.replace('team1_',
team1_stats['team'] = br_df['team1']
team1_stats['date'] = br_df['date']

team2_stats = br_df.filter(regex='team2').rename(columns=lambda x: x.replace('team2_',
team2_stats['team'] = br_df['team2']
team2_stats['date'] = br_df['date']

#concatenate and calculate cumulative stats
all_stats = pd.concat([team1_stats, team2_stats])
all_stats_grouped = all_stats.groupby(['team', 'date']).sum(numeric_only=True).groupby
all_stats_grouped['games_played'] = all_stats.groupby(['team', 'date']).size().groupby

#ensured indices are aligned properly
current_game_stats = all_stats.groupby(['team', 'date']).sum(numeric_only=True)
current_game_stats = current_game_stats.reindex(all_stats_grouped.index)

#calculated running averages by excluding current game stats
all_stats_grouped['games_played'] = all_stats_grouped['games_played'] - 1  # Decrement
avg_stats_per_game = (all_stats_grouped - current_game_stats)
avg_stats_per_game = avg_stats_per_game.div(all_stats_grouped['games_played'], axis=0)
```

```
# Handle division by zero for the first game
avg_stats_per_game = avg_stats_per_game.replace([np.inf, -np.inf], np.nan).fillna(0)
avg_stats_per_game.reset_index(inplace=True)

print(avg_stats_per_game)
```

```
            team        date        FGA    FG_pct        FTA    FT_pct  \
0        Atlanta  2023-11-01   0.000000  0.000000   0.000000  0.000000
1        Atlanta  2023-11-04  92.000000  0.500000  32.000000  0.906000
2        Atlanta  2023-11-06  92.500000  0.492000  28.000000  0.849000
3        Atlanta  2023-11-09  95.666667  0.452333  29.333333  0.847333
4        Atlanta  2023-11-11  93.000000  0.459750  29.500000  0.827250
...          ...         ...        ...       ...        ...       ...
2201  Washington  2024-03-29  91.457143  0.471600  20.071429  0.762443
2202  Washington  2024-03-31  91.408451  0.470718  19.901408  0.762268
2203  Washington  2024-04-02  91.361111  0.470500  19.916667  0.762264
2204  Washington  2024-04-03  91.383562  0.470973  19.876712  0.763110
2205  Washington  2024-04-05  91.378378  0.471297  19.783784  0.765270

            TOV        TRB        ast       blk   fg3_pct       fg3a  \
0      0.000000   0.000000   0.000000  0.000000  0.000000   0.000000
1     20.000000  57.000000  26.000000  3.000000  0.281000  32.000000
2     15.500000  54.500000  27.000000  4.500000  0.311000  36.500000
3     15.333333  56.000000  27.000000  4.000000  0.318333  38.333333
4     15.750000  51.000000  25.750000  4.750000  0.335000  38.500000
...         ...        ...        ...       ...       ...        ...
2201  13.571429  40.885714  28.071429  5.100000  0.349043  35.157143
2202  13.633803  40.971831  27.985915  5.084507  0.347972  35.126761
2203  13.652778  40.986111  27.972222  5.027778  0.347153  35.166667
2204  13.602740  41.027397  27.945205  4.986301  0.345644  35.205479
2205  13.662162  41.000000  27.918919  4.972973  0.346770  35.297297

      games_played       score       stl
0              0.0    0.000000  0.000000
1              0.0  130.000000  8.000000
2              0.0  126.500000  6.000000
3              0.0  123.333333  6.666667
4              0.0  122.500000  8.250000
...            ...         ...       ...
2201           0.0  113.742857  7.571429
2202           0.0  113.366197  7.492958
2203           0.0  113.277778  7.472222
2204           0.0  113.328767  7.493151
2205           0.0  113.418919  7.540541

[2206 rows x 15 columns]
```

In [77]:
```
#loading original data
br_df = pd.read_csv('br31.csv')

#making sure date is in datetime format
br_df['date'] = pd.to_datetime(br_df['date'])
avg_stats_per_game['date'] = pd.to_datetime(avg_stats_per_game['date'])

#creating unique indentifiers for merging
br_df['team_date'] = br_df['team1'].astype(str) + '_' + br_df['date'].dt.strftime('%Y-
avg_stats_per_game['team_date'] = avg_stats_per_game['team'].astype(str) + '_' + avg_s

#renaming date to avoid conflict
avg_stats_per_game = avg_stats_per_game.rename(columns={'date': 'date_avg'})
```

```
# Rename columns in avg_stats_per_game for team1
avg_stats_per_game_team1 = avg_stats_per_game.rename(columns=lambda x: x + '_avg1' if

# Merge the average statistics with the game results for team1
br_df = pd.merge(br_df, avg_stats_per_game_team1, on='team_date', how='left')

# Restore original 'date' column
br_df['date_avg1'] = br_df['date_avg']
br_df.drop(columns=['date_avg'], inplace=True)

# Update the unique identifiers for merging team2 statistics
br_df['team_date'] = br_df['team2'].astype(str) + '_' + br_df['date'].dt.strftime('%Y-

# Rename columns in avg_stats_per_game for team2
avg_stats_per_game_team2 = avg_stats_per_game.rename(columns=lambda x: x + '_avg2' if

# Merge the average statistics with the game results for team2
br_df = pd.merge(br_df, avg_stats_per_game_team2, on='team_date', how='left')

# Restore original 'date' column for team2
br_df['date_avg2'] = br_df['date_avg']
br_df.drop(columns=['date_avg'], inplace=True)

# Clean up unnecessary columns
columns_to_keep = [
    'date', 'team1', 'team1_score', 'team2', 'team2_score', 'Home_Team_ID', 'Away_Team
    'FGA_avg1', 'FG_pct_avg1', 'FTA_avg1', 'FT_pct_avg1', 'TOV_avg1', 'TRB_avg1', 'ast
    'fg3_pct_avg1', 'fg3a_avg1', 'score_avg1', 'stl_avg1', 'FGA_avg2', 'FG_pct_avg2',
    'TOV_avg2', 'TRB_avg2', 'ast_avg2', 'blk_avg2', 'fg3_pct_avg2', 'fg3a_avg2', 'scor
]
br_df = br_df[columns_to_keep]

#saved the final DataFrame
#br_df.to_csv('br33.csv', index=False)

print(br_df)
```

```
            date        team1  team1_score        team2  team2_score  \
0     2023-11-01   Washington          121      Atlanta          130   
1     2023-11-01      Indiana          104       Boston          155   
2     2023-11-01      Chicago          105       Dallas          114   
3     2023-11-01     Portland          110      Detroit          101   
4     2023-11-01   Sacramento          101  Golden State          102   
...          ...          ...          ...          ...          ...   
1098  2024-04-05      Detroit           90      Memphis          108   
1099  2024-04-05      Toronto          117    Milwaukee          111   
1100  2024-04-05  San Antonio          111  New Orleans          109   
1101  2024-04-05    Minnesota           87      Phoenix           97   
1102  2024-04-05     Portland          108   Washington          102   

      Home_Team_ID  Away_Team_ID  HomeWin  month   FGA_avg1  ...   FTA_avg2  \
0               22             0        1      0   0.000000  ...   0.000000   
1               20             1        1      0   0.000000  ...   0.000000   
2               17             2        1      0   0.000000  ...   0.000000   
3               13             3        0      0   0.000000  ...   0.000000   
4               19             4        1      0   0.000000  ...   0.000000   
...            ...           ...      ...    ...        ...  ...        ...   
1098            12            13        1      5  88.333333  ...  21.430556   
1099            11            14        0      5  89.875000  ...  24.150685   
1100            10            15        0      5  90.847222  ...  23.301370   
1101            24            28        1      5  84.863014  ...  23.763889   
1102             0             3        0      5  89.236111  ...  19.783784   

      FT_pct_avg2   TOV_avg2   TRB_avg2   ast_avg2  blk_avg2  fg3_pct_avg2  \
0        0.000000   0.000000   0.000000   0.000000  0.000000      0.000000   
1        0.000000   0.000000   0.000000   0.000000  0.000000      0.000000   
2        0.000000   0.000000   0.000000   0.000000  0.000000      0.000000   
3        0.000000   0.000000   0.000000   0.000000  0.000000      0.000000   
4        0.000000   0.000000   0.000000   0.000000  0.000000      0.000000   
...           ...        ...        ...        ...       ...           ...   
1098     0.757750  14.180556  42.347222  25.041667  6.208333      0.346667   
1099     0.769904  11.986301  44.465753  26.890411  5.095890      0.375247   
1100     0.771411  12.260274  44.191781  27.136986  4.739726      0.377164   
1101     0.802083  13.930556  44.125000  27.236111  6.069444      0.382958   
1102     0.765270  13.662162  41.000000  27.918919  4.972973      0.346770   

      fg3a_avg2  score_avg2  stl_avg2  
0      0.000000    0.000000  0.000000  
1      0.000000    0.000000  0.000000  
2      0.000000    0.000000  0.000000  
3      0.000000    0.000000  0.000000  
4      0.000000    0.000000  0.000000  
...         ...         ...       ...  
1098  38.138889  106.013889  7.930556  
1099  38.383562  120.136986  6.684932  
1100  32.191781  115.589041  8.246575  
1101  32.222222  117.194444  7.222222  
1102  35.297297  113.418919  7.540541  

[1103 rows x 33 columns]
```

Over/Under Prediction With RandomForestClassifier and BR33 Dataframe That Uses Rolling Averages

In [78]:

```
br_df = pd.read_csv('br33.csv')
#dropping rows with 0s
br_df = br_df[(br_df['FGA_avg1'] != 0)
              ]
br_df = br_df.reset_index(drop = True)
threshold = 220
br_df['OverUnder'] = (br_df['team2_score'] + br_df['team1_score'] > threshold).astype(
#astype coverts boolean to integer 0 and 1


print(br_df)
br_cool = br_df
```

```
            date        team1  team1_score         team2  team2_score  \
0     2023-11-02      Detroit          116   New Orleans          125
1     2023-11-02      Toronto           99  Philadelphia          114
2     2023-11-03     Brooklyn          109       Chicago          107
3     2023-11-03       Dallas          114        Denver          125
4     2023-11-03    Cleveland          116       Indiana          121
...          ...          ...          ...           ...          ...
1083  2024-04-05      Detroit           90       Memphis          108
1084  2024-04-05      Toronto          117      Milwaukee         111
1085  2024-04-05  San Antonio          111   New Orleans          109
1086  2024-04-05    Minnesota           87       Phoenix           97
1087  2024-04-05     Portland          108    Washington          102

      Home_Team_ID  Away_Team_ID  HomeWin  month   FGA_avg1  ...  FT_pct_avg2  \
0               10            13        1      0  90.000000  ...     0.586000
1               26            14        1      0  91.000000  ...     0.000000
2                2             7        0      0  82.000000  ...     0.909000
3                8            17        1      0  81.000000  ...     0.700000
4                1             9        1      0  74.000000  ...     0.583000
...            ...           ...      ...    ...        ...  ...          ...
1083            12            13        1      5  88.333333  ...     0.757750
1084            11            14        0      5  89.875000  ...     0.769904
1085            10            15        0      5  90.847222  ...     0.771411
1086            24            28        1      5  84.863014  ...     0.802083
1087             0             3        0      5  89.236111  ...     0.765270

       TOV_avg2   TRB_avg2   ast_avg2   blk_avg2  fg3_pct_avg2  fg3a_avg2  \
0     10.000000  58.000000  23.000000   5.000000      0.310000  42.000000
1      0.000000   0.000000   0.000000   0.000000      0.000000   0.000000
2     13.000000  43.000000  19.000000   3.000000      0.333000  33.000000
3     15.000000  43.000000  23.000000  10.000000      0.182000  33.000000
4      9.000000  31.000000  26.000000   6.000000      0.135000  37.000000
...         ...        ...        ...        ...           ...        ...
1083  14.180556  42.347222  25.041667   6.208333      0.346667  38.138889
1084  11.986301  44.465753  26.890411   5.095890      0.375247  38.383562
1085  12.260274  44.191781  27.136986   4.739726      0.377164  32.191781
1086  13.930556  44.125000  27.236111   6.069444      0.382958  32.222222
1087  13.662162  41.000000  27.918919   4.972973      0.346770  35.297297

      score_avg2   stl_avg2  OverUnder
0     110.000000   8.000000          1
1       0.000000   0.000000          0
2     105.000000  10.000000          0
3      89.000000   6.000000          1
4     104.000000   6.000000          1
...          ...        ...        ...
1083  106.013889   7.930556          0
1084  120.136986   6.684932          1
1085  115.589041   8.246575          0
1086  117.194444   7.222222          0
1087  113.418919   7.540541          0

[1088 rows x 34 columns]
```

In [79]:
```
numeric_data = br_df.drop(['date', 'month', 'team1_score', 'team2_score', 'OverUnder',
                           'HomeWin', 'team1', 'team2'], axis = 1).values


X = numeric_data
```

```
y = br_df['OverUnder'].values

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=
```

In [80]:
```
rf = RandomForestClassifier(random_state=42, n_jobs=-1)

params = {
    'max_depth': [2,3,5,10,20],
    'min_samples_leaf': [5,10,20,50,100,200],
    'n_estimators': [10,25,30,50,100,200]
}

from sklearn.model_selection import GridSearchCV

# Instantiate the grid search model
grid_search = GridSearchCV(estimator=rf,
                           param_grid=params,
                           cv = 4,
                           n_jobs=-1, verbose=1, scoring="accuracy")

grid_search.fit(X_train, y_train)
```

```
Fitting 4 folds for each of 180 candidates, totalling 720 fits
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 2 concurrent workers.
[Parallel(n_jobs=-1)]: Done  46 tasks      | elapsed:   11.4s
[Parallel(n_jobs=-1)]: Done 196 tasks      | elapsed:   34.1s
[Parallel(n_jobs=-1)]: Done 446 tasks      | elapsed:  1.3min
[Parallel(n_jobs=-1)]: Done 720 out of 720 | elapsed:  2.2min finished
```

Out[80]:
```
GridSearchCV(cv=4, error_score=nan,
             estimator=RandomForestClassifier(bootstrap=True, ccp_alpha=0.0,
                                              class_weight=None,
                                              criterion='gini', max_depth=None,
                                              max_features='auto',
                                              max_leaf_nodes=None,
                                              max_samples=None,
                                              min_impurity_decrease=0.0,
                                              min_impurity_split=None,
                                              min_samples_leaf=1,
                                              min_samples_split=2,
                                              min_weight_fraction_leaf=0.0,
                                              n_estimators=100, n_jobs=-1,
                                              oob_score=False, random_state=42,
                                              verbose=0, warm_start=False),
             iid='deprecated', n_jobs=-1,
             param_grid={'max_depth': [2, 3, 5, 10, 20],
                         'min_samples_leaf': [5, 10, 20, 50, 100, 200],
                         'n_estimators': [10, 25, 30, 50, 100, 200]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring='accuracy', verbose=1)
```

In [81]:
```
print(grid_search.best_score_)
rf_best = grid_search.best_estimator_
print(rf_best)
```

```
0.6459909947998139
RandomForestClassifier(bootstrap=True, ccp_alpha=0.0, class_weight=None,
                       criterion='gini', max_depth=5, max_features='auto',
                       max_leaf_nodes=None, max_samples=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=20, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=200,
                       n_jobs=-1, oob_score=False, random_state=42, verbose=0,
                       warm_start=False)
```

In [82]:

```
# Instantiate the model
rf = RandomForestClassifier(bootstrap=True, ccp_alpha=0.0, class_weight=None,
                       criterion='gini', max_depth=5, max_features='auto',
                       max_leaf_nodes=None, max_samples=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=20, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=200,
                       n_jobs=-1, oob_score=False, verbose=0,
                       warm_start=False)



# Train the model
rf.fit(X_train, y_train)

# Make predictions
y_pred = rf.predict(X_test)
#print(rf.oob_score_)
# Evaluate the model
accuracy = accuracy_score(y_test, y_pred)
print(f'Accuracy: {accuracy}')
```

```
Accuracy: 0.6697247706422018
```

With standard scaling and onehot encoding

In [83]:

```
cat = br_df[['Home_Team_ID', 'Away_Team_ID']].values
encoder = OneHotEncoder()
cat_ohe = encoder.fit_transform(cat).toarray()

numeric_data = br_df.drop(['date', 'month', 'team1_score', 'team2_score', 'OverUnder',
                           'Home_Team_ID', 'Away_Team_ID', 'HomeWin', 'team1', 'team2'
scaler = StandardScaler()
x_norm = scaler.fit_transform(numeric_data)
X = np.hstack((x_norm, cat_ohe))
print(X.shape)

y = br_df['OverUnder'].values

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=

# Instantiate the model
rf = RandomForestClassifier(bootstrap=True, ccp_alpha=0.0, class_weight=None,
                       criterion='gini', max_depth=5, max_features='auto',
                       max_leaf_nodes=None, max_samples=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=20, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=200,
                       n_jobs=-1, oob_score=False, verbose=0,
```

```
                       warm_start=False)


# Train the model
rf.fit(X_train, y_train)

# Make predictions
y_pred = rf.predict(X_test)
#print(rf.oob_score_)
# Evaluate the model
accuracy = accuracy_score(y_test, y_pred)
print(f'Accuracy: {accuracy}')
```

```
(1088, 84)
Accuracy: 0.6880733944954128
```

Invidivual match prediction

In [84]:
```
br_df = pd.read_csv('br33.csv')
#dropping rows with 0s
br_df = br_df[(br_df['FGA_avg1'] != 0)
             ]
br_df = br_df.reset_index(drop = True)

print(br_df)
br_cool = br_df
```

```
            date        team1  team1_score         team2  team2_score  \
0     2023-11-02      Detroit          116   New Orleans          125   
1     2023-11-02      Toronto           99  Philadelphia          114   
2     2023-11-03     Brooklyn          109       Chicago          107   
3     2023-11-03       Dallas          114        Denver          125   
4     2023-11-03    Cleveland          116       Indiana          121   
...          ...          ...          ...           ...          ...   
1083  2024-04-05      Detroit           90       Memphis          108   
1084  2024-04-05      Toronto          117     Milwaukee          111   
1085  2024-04-05  San Antonio          111   New Orleans          109   
1086  2024-04-05    Minnesota           87       Phoenix           97   
1087  2024-04-05     Portland          108    Washington          102   

      Home_Team_ID  Away_Team_ID  HomeWin  month   FGA_avg1  ...   FTA_avg2  \
0               10            13        1      0  90.000000  ...  29.000000   
1               26            14        1      0  91.000000  ...   0.000000   
2                2             7        0      0  82.000000  ...  11.000000   
3                8            17        1      0  81.000000  ...  10.000000   
4                1             9        1      0  74.000000  ...  12.000000   
...            ...           ...      ...    ...        ...  ...        ...   
1083            12            13        1      5  88.333333  ...  21.430556   
1084            11            14        0      5  89.875000  ...  24.150685   
1085            10            15        0      5  90.847222  ...  23.301370   
1086            24            28        1      5  84.863014  ...  23.763889   
1087             0             3        0      5  89.236111  ...  19.783784   

      FT_pct_avg2   TOV_avg2   TRB_avg2   ast_avg2   blk_avg2  fg3_pct_avg2  \
0        0.586000  10.000000  58.000000  23.000000   5.000000      0.310000   
1        0.000000   0.000000   0.000000   0.000000   0.000000      0.000000   
2        0.909000  13.000000  43.000000  19.000000   3.000000      0.333000   
3        0.700000  15.000000  43.000000  23.000000  10.000000      0.182000   
4        0.583000   9.000000  31.000000  26.000000   6.000000      0.135000   
...           ...        ...        ...        ...        ...           ...   
1083     0.757750  14.180556  42.347222  25.041667   6.208333      0.346667   
1084     0.769904  11.986301  44.465753  26.890411   5.095890      0.375247   
1085     0.771411  12.260274  44.191781  27.136986   4.739726      0.377164   
1086     0.802083  13.930556  44.125000  27.236111   6.069444      0.382958   
1087     0.765270  13.662162  41.000000  27.918919   4.972973      0.346770   

      fg3a_avg2  score_avg2   stl_avg2  
0     42.000000  110.000000   8.000000  
1      0.000000    0.000000   0.000000  
2     33.000000  105.000000  10.000000  
3     33.000000   89.000000   6.000000  
4     37.000000  104.000000   6.000000  
...         ...         ...        ...  
1083  38.138889  106.013889   7.930556  
1084  38.383562  120.136986   6.684932  
1085  32.191781  115.589041   8.246575  
1086  32.222222  117.194444   7.222222  
1087  35.297297  113.418919   7.540541  

[1088 rows x 33 columns]
```

With OHE and Standard Scaling

In [59]:
```
team_names = {
  0: 'Washington',
```

```
    1: 'Indiana',
    2: 'Chicago',
    3: 'Portland',
    4: 'Sacramento',
    5: 'Charlotte',
    6: 'LA Clippers',
    7: 'Brooklyn',
    8: 'Denver',
    9: 'Cleveland',
    10: 'New Orleans',
    11: 'Milwaukee',
    12: 'Memphis',
    13: 'Detroit',
    14: 'Toronto',
    15: 'San Antonio',
    16: 'Orlando',
    17: 'Dallas',
    18: 'New York',
    19: 'Golden State',
    20: 'Boston',
    21: 'Utah',
    22: 'Atlanta',
    23: 'LA Lakers',
    24: 'Phoenix',
    25: 'Miami',
    26: 'Philadelphia',
    27: 'Oklahoma City',
    28: 'Minnesota',
    29: 'Houston'
}

def prepare_features(home_stats, away_stats):
    """
    Prepares the numeric feature vector from home and away team stats.
    Uses suffixes '_1' for home team stats and '_2' for away team stats as per the dat
    """
    #stats list for home and away teams as per suffix conventions
    home_stats_list = [
        'FGA_avg1', 'FG_pct_avg1', 'FTA_avg1', 'FT_pct_avg1', 'TOV_avg1',
        'TRB_avg1', 'ast_avg1', 'blk_avg1', 'fg3_pct_avg1', 'fg3a_avg1',
        'score_avg1', 'stl_avg1'
    ]
    away_stats_list = [
        'FGA_avg2', 'FG_pct_avg2', 'FTA_avg2', 'FT_pct_avg2', 'TOV_avg2',
        'TRB_avg2', 'ast_avg2', 'blk_avg2', 'fg3_pct_avg2', 'fg3a_avg2',
        'score_avg2', 'stl_avg2'
    ]

    #extract the respective stats for home and away teams
    home_features = home_stats[home_stats_list].values.flatten()
    away_features = away_stats[away_stats_list].values.flatten()

    #combine home and away features
    return np.hstack([home_features, away_features])

def get_latest_team_stats(team_stats_df, team_id, home = None):
    """
    Retrieves the latest stats for a given team_id based on the most recent date.
    """
    if home is not None:
```

```
        team_data = team_stats_df[team_stats_df['Home_Team_ID'] == team_id]
        latest_entry = team_data.sort_values(by='date', ascending=False).iloc[0]
    else:
        team_data = team_stats_df[team_stats_df['Away_Team_ID'] == team_id]
        latest_entry = team_data.sort_values(by='date', ascending=False).iloc[0]
    return latest_entry

def predict_tomorrow_games(matchups, team_stats_df, thresholds):
    predictions = []

    all_team_ids = np.unique(team_stats_df[['Home_Team_ID', 'Away_Team_ID']].values.fl
    encoder = OneHotEncoder(categories=[all_team_ids, all_team_ids])
    scaler = StandardScaler()

    #preparing the numeric data for scaling and categorical data for encoding
    numeric_columns = team_stats_df.drop(['date',
                                          'month',
                                          'team1_score',
                                          'team2_score',
                                          'Home_Team_ID',
                                          'Away_Team_ID',
                                          'HomeWin',
                                          'team1',
                                          'team2'], axis = 1).values
    x_norm = scaler.fit_transform(numeric_columns)
    cat = team_stats_df[['Home_Team_ID', 'Away_Team_ID']].values
    cat_ohe = encoder.fit_transform(cat).toarray()
    X = np.hstack((x_norm, cat_ohe))  # Full feature set for training



    for index, (home_id, away_id) in enumerate(matchups):
        threshold = thresholds[index]
        probabilities_list = []
        accuracy_list = []
        team_stats_df2 = team_stats_df.copy(deep=True)

        for _ in range(20):

            team_stats_df2['OverUnder'] = (team_stats_df['team2_score'] + team_stats_c
            y = team_stats_df2['OverUnder'].values

            #split data for training and testing
            X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.25)
            rf = RandomForestClassifier(n_estimators=200)
            rf.fit(X_train, y_train)
            y_pred = rf.predict(X_test)
            accuracy = accuracy_score(y_test, y_pred)
            accuracy_list.append(accuracy)

            # prepare features for prediction for the current game
            home_stats = get_latest_team_stats(team_stats_df2, home_id, home=True)
            away_stats = get_latest_team_stats(team_stats_df2, away_id, home=None)
            numeric_features = prepare_features(home_stats, away_stats)
            numeric_features = scaler.fit_transform(numeric_features.reshape(1, -1))
            categorical_features = np.array([[home_id, away_id]])
            encoded_features = encoder.transform(categorical_features).toarray()

            game_features = np.hstack((encoded_features, numeric_features))
```

```
            # Predict probabilities and store them
            probabilities = rf.predict_proba(game_features)[0, 1]
            probabilities_list.append(probabilities)

        #average the probabilities and accuracies for current matchup
        avg_probability = np.mean(probabilities_list)
        avg_accuracy = np.mean(accuracy_list)
        final_decision = "Over" if avg_probability > 0.5 else "Under"
        confidence = "High Confidence" if avg_probability >= 0.60 or avg_probability <

        predictions.append((team_names[home_id], team_names[away_id], round(avg_accura

    return predictions
```

In [60]:

```
#march 20 to 21st ish 2023
# 12 correct and only 1 wrong
#WOW!

matchup = [(25, 2), (10, 4), (28, 2)] # Home team is (HERE, NOT HERE)
threshold = [207, 210, 200]


predict_tomorrow_games(matchups=matchup,
                       team_stats_df=br_cool,
                       thresholds=threshold)
```

Out[60]:

```
[('Miami', 'Chicago', 0.858, 207, 0.944, 'Over', 'High Confidence'),
 ('New Orleans', 'Sacramento', 0.807, 210, 0.824, 'Over', 'High Confidence'),
 ('Minnesota', 'Chicago', 0.932, 200, 0.986, 'Over', 'High Confidence')]
```

Without Standard Scaling and One Hot Encoding

In [57]:

```
team_names = {
    0: 'Washington', 1: 'Indiana', 2: 'Chicago', 3: 'Portland', 4: 'Sacramento',
    5: 'Charlotte', 6: 'LA Clippers', 7: 'Brooklyn', 8: 'Denver', 9: 'Cleveland',
    10: 'New Orleans', 11: 'Milwaukee', 12: 'Memphis', 13: 'Detroit', 14: 'Toronto',
    15: 'San Antonio', 16: 'Orlando', 17: 'Dallas', 18: 'New York', 19: 'Golden State'
    20: 'Boston', 21: 'Utah', 22: 'Atlanta', 23: 'LA Lakers', 24: 'Phoenix', 25: 'Miam
    26: 'Philadelphia', 27: 'Oklahoma City', 28: 'Minnesota', 29: 'Houston'
}

def prepare_features(home_stats, away_stats):
    """
    Prepares the numeric feature vector from home and away team stats.
    Uses suffixes '_avg1' for home team stats and '_avg2' for away team stats as per t
    """

    home_stats_list = [
        'FGA_avg1', 'FG_pct_avg1', 'FTA_avg1', 'FT_pct_avg1', 'TOV_avg1',
        'TRB_avg1', 'ast_avg1', 'blk_avg1', 'fg3_pct_avg1', 'fg3a_avg1',
        'score_avg1', 'stl_avg1'
    ]
    away_stats_list = [
        'FGA_avg2', 'FG_pct_avg2', 'FTA_avg2', 'FT_pct_avg2', 'TOV_avg2',
        'TRB_avg2', 'ast_avg2', 'blk_avg2', 'fg3_pct_avg2', 'fg3a_avg2',
        'score_avg2', 'stl_avg2'
```

```
    ]


    home_features = home_stats[home_stats_list].values.flatten()
    away_features = away_stats[away_stats_list].values.flatten()


    return np.hstack([home_features, away_features])

def get_latest_team_stats(team_stats_df, team_id, home=None):
    """
    Retrieves the latest stats for a given team_id based on the most recent date.
    """
    if home:
        team_data = team_stats_df[team_stats_df['Home_Team_ID'] == team_id]
    else:
        team_data = team_stats_df[team_stats_df['Away_Team_ID'] == team_id]

    latest_entry = team_data.sort_values(by='date', ascending=False).iloc[0]
    return latest_entry

def predict_tomorrow_games(matchups, team_stats_df, thresholds):
    predictions = []

    for index, (home_id, away_id) in enumerate(matchups):
        threshold = thresholds[index]
        probabilities_list = []
        accuracy_list = []

        team_stats_df2 = team_stats_df.copy(deep=True)
        for _ in range(20):
            team_stats_df2['OverUnder'] = (team_stats_df2['team2_score'] + team_stats_
            y = team_stats_df2['OverUnder'].values

            # Prepare numeric features and categorical team IDs for training
            numeric_columns = team_stats_df2.drop(columns=['date', 'month', 'team1_sco
            X_numeric = numeric_columns.values
            X_team_ids = team_stats_df2[['Home_Team_ID', 'Away_Team_ID']].values
            X = np.hstack((X_numeric, X_team_ids))


            X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.25,
            rf = RandomForestClassifier(n_estimators=200, random_state=42)
            rf.fit(X_train, y_train)
            y_pred = rf.predict(X_test)
            accuracy = accuracy_score(y_test, y_pred)
            accuracy_list.append(accuracy)


            home_stats = get_latest_team_stats(team_stats_df2, home_id, home=True)
            away_stats = get_latest_team_stats(team_stats_df2, away_id, home=False)
            numeric_features = prepare_features(home_stats, away_stats)
            game_features = np.hstack((numeric_features, [home_id, away_id])).reshape(


            probabilities = rf.predict_proba(game_features)[0, 1]
            probabilities_list.append(probabilities)


        avg_probability = np.mean(probabilities_list)
```

```python
        avg_accuracy = np.mean(accuracy_list)
        final_decision = "Over" if avg_probability > 0.5 else "Under"
        confidence = "High Confidence" if avg_probability >= 0.60 or avg_probability <

        predictions.append((team_names[home_id], team_names[away_id], round(avg_accura

    return predictions
```

In [58]:
```python
matchup = [(25, 2), (10, 4), (28, 2)] # Home team is (HERE, NOT HERE)
threshold = [207, 210, 200]


predict_tomorrow_games(matchups=matchup,
                       team_stats_df=br_cool,
                       thresholds=threshold)
```

Out[58]:
```
[('Miami', 'Chicago', 0.86, 207, 0.815, 'Over', 'High Confidence'),
 ('New Orleans', 'Sacramento', 0.812, 210, 0.65, 'Over', 'High Confidence'),
 ('Minnesota', 'Chicago', 0.934, 200, 0.895, 'Over', 'High Confidence')]
```