In [ ]:
```
from itertools import product
import pandas as pd
import numpy as np
from sklearn.linear_model import LinearRegression
import matplotlib.pyplot as plt
import seaborn as sns
import warnings

warnings.simplefilter(action="ignore", category=FutureWarning)
```

Notes:

- Based on boxplots it seems that big jump from 2020 to 2021 and 2022 seasons
- Starting in 2021, the number of athletes recorded is 50 instead of 75 (maybe we should only keep top 50 for consistency in other years)
- 2020 may be a transition year for supershoes, could throw it out because they are not fully adopted, plus covid/masking while running makes it a weird year.
- Here I assign ordinal values to class year, but maybe we should use dummy vars instead. Same for yearOrdinal

In [ ]:
```
events = ["mile", "3000m", "5000m"]
gender = ["f", "m"]
years = list(np.arange(2016, 2023, 1))

combinations = list(product(events, gender, years))

# preprocess and concatenate data from all genders, events, and years
for event, gender, year in combinations:
    temp = pd.read_csv(f"data/{year}_{year+1}_{event}_{gender}.csv")
    # one-hot encode gender
    temp["gender"] = 0 if gender == "f" else 1

    # infer whether supershoes were worn based on year
    # (Nike Dragonfly released in Aug 2020)
    temp["supershoes"] = 1 if year >= 2021 else 0

    # maintain ordinal value for year (may need to scale later)
    temp["year"] = int(year)
    temp["yearOrdinal"] = int(year-2015)

    # add event column
    temp["event"] = event

    if year == 2016 and gender == "f" and event == "mile":
        data = temp
    else:
        data = pd.concat([data, temp], sort=False)

# Assign ordinal values to class year?
# fill NAN values with another class. 5 = other.
# Typically this happens because of a redshirt season or later injury
```

```
# only happens for 6 people in whole dataset
data = data.rename(columns={"Year": "ClassYear"})
data["ClassYear"] = data["ClassYear"].str[0:2].map({"FR": 1, "SO": 2, "JR":
data["ClassYear"] = data["ClassYear"].fillna(5)

data["dummy"] = data["event"]
# add dummy variables for event
data = pd.get_dummies(data, columns=["dummy"])
```

In [ ]:
```
data.describe()
```

Out[ ]:

	Rank	ClassYear	Time_seconds	gender	supershoes	
count	2850.000000	2850.000000	2850.000000	2850.000000	2850.000000	2850.00
mean	35.347719	2.907018	556.528189	0.500000	0.210526	2018.73
std	20.968063	1.018667	266.347979	0.500088	0.407754	1.9
min	1.000000	1.000000	230.390000	0.000000	0.000000	2016.00
25%	17.000000	2.000000	278.912500	0.000000	0.000000	2017.00
50%	34.000000	3.000000	501.380000	0.500000	0.000000	2019.00
75%	52.000000	4.000000	832.245000	1.000000	0.000000	2020.00
max	75.000000	5.000000	1004.970000	1.000000	1.000000	2022.00

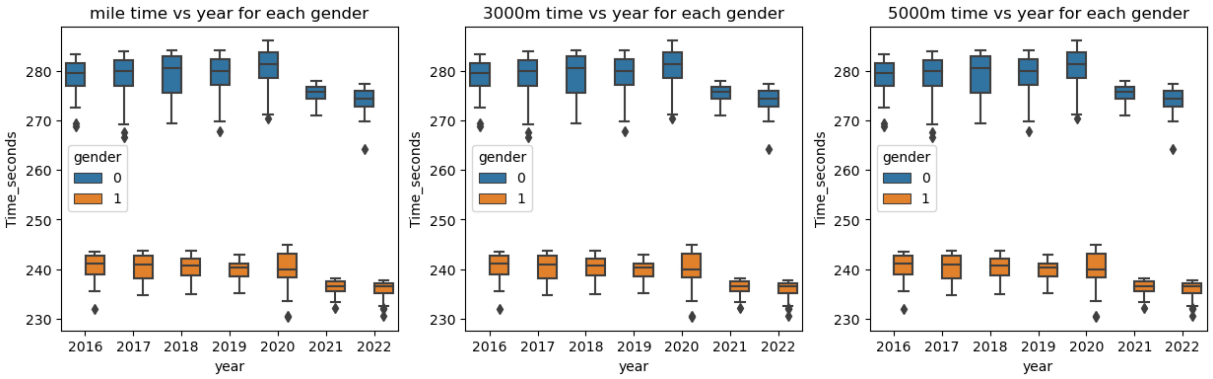
In [ ]:
```
data.head()
```

Out[ ]:

	Rank	Athlete	ClassYear	Team	Time	Meet	Meet_Date	Time_seco
0	1	Edwards, Kaela	4.0	Oklahoma State	4:28.75	110th NYRR Millrose Games	Feb 11, 2017	26
1	2	Purrier, Elinor	3.0	New Hampshire	4:29.44	110th NYRR Millrose Games	Feb 11, 2017	26
2	3	Rivers, Danae	1.0	Penn State	4:32.55	2017 Husky Classic	Feb 10, 2017	27
3	4	Jones, Dani	2.0	Colorado	4:32.68\n@	Colorado Open	Feb 2, 2017	27
4	5	Cleirigh Buttner, Siofra	3.0	Villanova	4:33.16	Fastrack National Invite	Feb 10, 2017	27

In [ ]:
```
# Make boxplots for each year/gender and event
fig, axs = plt.subplots(1, 3, figsize=(15, 4))
for event, ax in zip(events, axs):
    temp = data[(data["event"] == "mile")]
```

```
    sns.boxplot(x="year", y="Time_seconds", ax=ax, data=temp, hue="gender").
        title=f"{event} time vs year for each gender"
    )
```



In [ ]:
```
# helper function to build eqn string and save supershoe coefficients
def build_eqn(model, cols, supershoe_coefs=[]):
    eqn = f"{np.round(model.intercept_, 3)} + "
    for coef, col in zip(model.coef_, cols):
        if col == "supershoes": supershoe_coefs.append(coef)
        eqn += f"({np.round(coef, 3)})*{col} + "
    return eqn[:-2], supershoe_coefs

# Linear Regression
# only fit on relevant columns for x data
print(f"Linear fit results for all predictors:")
temp = data
x_cols = [
    "dummy_5000m",
    "dummy_3000m",
    "dummy_mile",
    "gender",
    "supershoes",
    "yearOrdinal",
    "Rank",
    "ClassYear",
]
x = temp[x_cols]
y = temp["Time_seconds"]
# create linear regression model
model = LinearRegression().fit(x, y)
print(f"R^2: {model.score(x, y)}")
eqn, _ = build_eqn(model, x_cols)
print(f"Equation: Time_seconds = {eqn}")
```

```
Linear fit results for all predictors:
R^2: 0.9941212519054592
Equation: Time_seconds = 586.879 + (340.273)*dummy_5000m + (-42.721)*dummy_3
000m + (-297.553)*dummy_mile + (-82.417)*gender + (-10.031)*supershoes + (0.
435)*yearOrdinal + (0.366)*Rank + (-0.553)*ClassYear
```

In [ ]:
```
# Now we split out the data by event and fit a linear
# regression model for each event separately
supershoe_coefs = []
for event in events:
```

```
    print(f"\nEvent: {event} linear fit results:")
    temp = data[(data["event"] == event)]
    x_cols = [
        "gender",
        "supershoes",
        "yearOrdinal",
        "Rank",
        "ClassYear",
    ]
    x = temp[x_cols]
    y = temp["Time_seconds"]
    # create linear regression model
    model = LinearRegression().fit(x, y)
    print(f"R^2: {model.score(x, y)}")
    eqn, supershoe_coefs = build_eqn(model, x_cols, supershoe_coefs)
    print(f"Equation: Time_seconds = {eqn}")
```

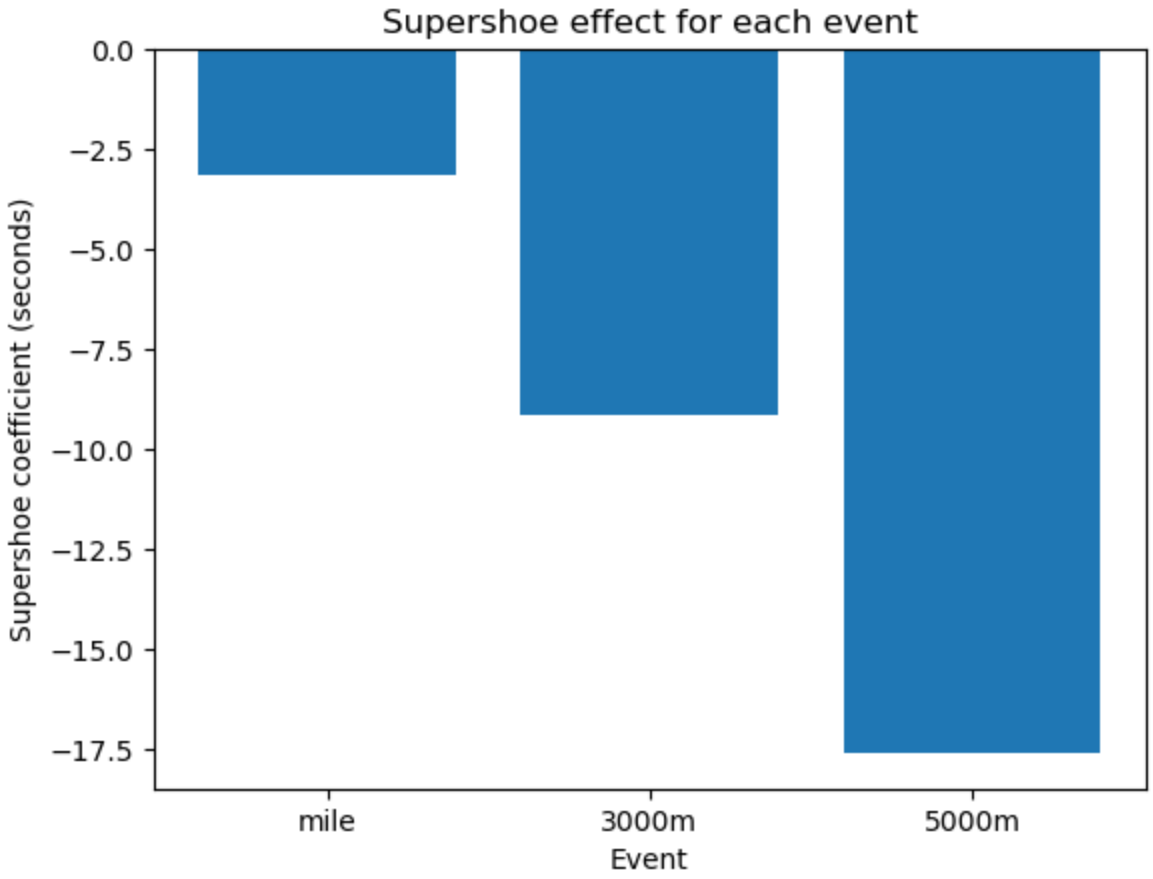
```
Event: mile linear fit results:
R^2: 0.996384214148695
Equation: Time_seconds = 274.162 + (-39.043)*gender + (-3.136)*supershoes +
(0.095)*yearOrdinal + (0.136)*Rank + (-0.061)*ClassYear

Event: 3000m linear fit results:
R^2: 0.9940553725223424
Equation: Time_seconds = 541.246 + (-75.442)*gender + (-9.139)*supershoes +
(0.301)*yearOrdinal + (0.32)*Rank + (-0.08)*ClassYear

Event: 5000m linear fit results:
R^2: 0.9910689213213725
Equation: Time_seconds = 941.113 + (-132.741)*gender + (-17.582)*supershoes
+ (0.928)*yearOrdinal + (0.648)*Rank + (-0.216)*ClassYear
```

In [ ]:
```
# Plot bar plot of effect as measured by coefficients
plt.bar(events, supershoe_coefs)
plt.ylabel("Supershoe coefficient (seconds)")
plt.xlabel("Event")
plt.title(f"Supershoe effect for each event")
```

Out[ ]:
```
Text(0.5, 1.0, 'Supershoe effect for each event')
```



In [ ]:
```python
# Here we separate the equations by gender and event to see
# if there are differences in the effect of supershoes across
# events or genders
fig, axs = plt.subplots(1, 3, figsize=(18, 4))
for event, ax in zip(events, axs):
    print(f"\nEvent: {event} linear fit results:")
    supershoe_coefs = []
    for gender in [0, 1]:
        temp = data[(data["event"] == event) & (data["gender"] == gender)]
        x_cols = [
            "supershoes",
            "yearOrdinal",
            "Rank",
            "ClassYear",
        ]
        x = temp[x_cols]
        y = temp["Time_seconds"]
        # create linear regression model
        model = LinearRegression().fit(x, y)
        print(f"R^2: {model.score(x, y)}")
        eqn, supershoe_coefs = build_eqn(model, x_cols, supershoe_coefs)
        print(f"Equation for gender {gender}: Time_seconds = {eqn}")
    ax.bar(["Female", "Male"], supershoe_coefs)
    ax.set_ylabel("Supershoe coefficient (seconds)")
    ax.set_xlabel("Gender")
    ax.set_title(f"Supershoe effect for {event}")
```

```
Event: mile linear fit results:
R^2: 0.9146676083919167
Equation for gender 0: Time_seconds = 272.465 + (-3.82)*supershoes + (0.326)
*yearOrdinal + (0.165)*Rank + (-0.071)*ClassYear
R^2: 0.9331566909970163
Equation for gender 1: Time_seconds = 236.745 + (-2.452)*supershoes + (-0.13
4)*yearOrdinal + (0.108)*Rank + (-0.028)*ClassYear

Event: 3000m linear fit results:
R^2: 0.9088092931258234
Equation for gender 0: Time_seconds = 538.302 + (-10.123)*supershoes + (0.53
5)*yearOrdinal + (0.397)*Rank + (-0.232)*ClassYear
R^2: 0.940954610811211
Equation for gender 1: Time_seconds = 469.144 + (-8.182)*supershoes + (0.06
6)*yearOrdinal + (0.243)*Rank + (-0.058)*ClassYear

Event: 5000m linear fit results:
R^2: 0.8870439782792399
Equation for gender 0: Time_seconds = 929.818 + (-21.359)*supershoes + (2.88
4)*yearOrdinal + (0.796)*Rank + (-0.369)*ClassYear
R^2: 0.9603711795223497
Equation for gender 1: Time_seconds = 820.47 + (-13.87)*supershoes + (-1.02
3)*yearOrdinal + (0.499)*Rank + (-0.325)*ClassYear
```