

Rio 2016 Olympics Data Analysis

April 12, 2018

```
In [4]: #import statements for visualization and data analysis
import pandas as pd
import numpy as np
from pandas import DataFrame as df
import matplotlib.pyplot as plt
from datetime import datetime
from datetime import date
import seaborn as sns
import math
import random
from math import sqrt
from scipy import stats
from sklearn.svm import SVC
from sklearn.model_selection import GridSearchCV
import warnings
warnings.filterwarnings("ignore")
from mpl_toolkits.mplot3d import Axes3D
from numpy.linalg import pinv
```

0.1 Initialize Data

Import 'athletes.csv' and store the data in a DataFrame

```
In [5]: ath_data = pd.read_csv('athletes.csv', index_col=0)
dobs = ath_data['dob'].values
#calculates the person's age
ages = []
for i in range(dobs.size):
    dob = datetime.strptime((dobs[i]), '%m/%d/%Y')
    age = int((date.today()-dob.date()).days/365)
    ages.append(age)
#appends the list of age to the existing DataFrame
ath_data['age']=ages
#appends the total amount of medals earned from an athlete to the DataFrame
col_list=['gold', 'silver', 'bronze']
ath_data['totals'] = ath_data[col_list].sum(axis=1)
```

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col_list = ['height', 'weight', 'age', 'sex']
physical=ath_data[col_list]
physical = physical[physical.height.notnull()]
physical = physical[physical.weight.notnull()]
physical['BMI'] = (physical[col_list].sum(axis=1))/(physical['height']**2

col_list = ['height', 'weight']
physical2 = physical
physical2['sport'] = ath_data['sport']

```

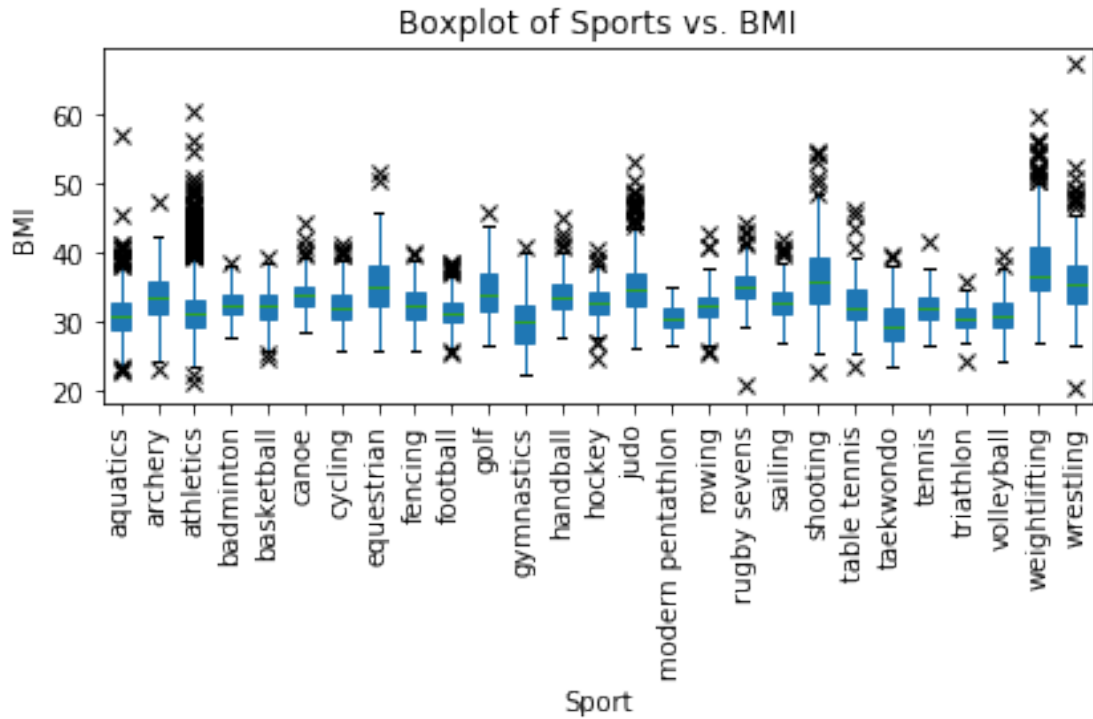
1 Investigation 1: Comparing Mean BMI Across Gymnastics, Aquatics, and Weightlifting

Is the mean height/weight distribution (i.e BMI) equal across aquatics, gymnastics, and weightlifting? If not, which sports have different means?

```

In [78]: #plots boxplot of the BMI distribution by sports
plot = physical.boxplot(column = 'BMI', by='sport', patch_artist=True,
                        flierprops=dict(marker='x', color='cyan'))
plot.grid(False)
plot.set_xlabel('Sport')
plot.set_ylabel('BMI')
plt.title("Boxplot of Sports vs. BMI")
plt.suptitle("")
plt.xticks(rotation=90)
plt.tight_layout()
plt.show()

```



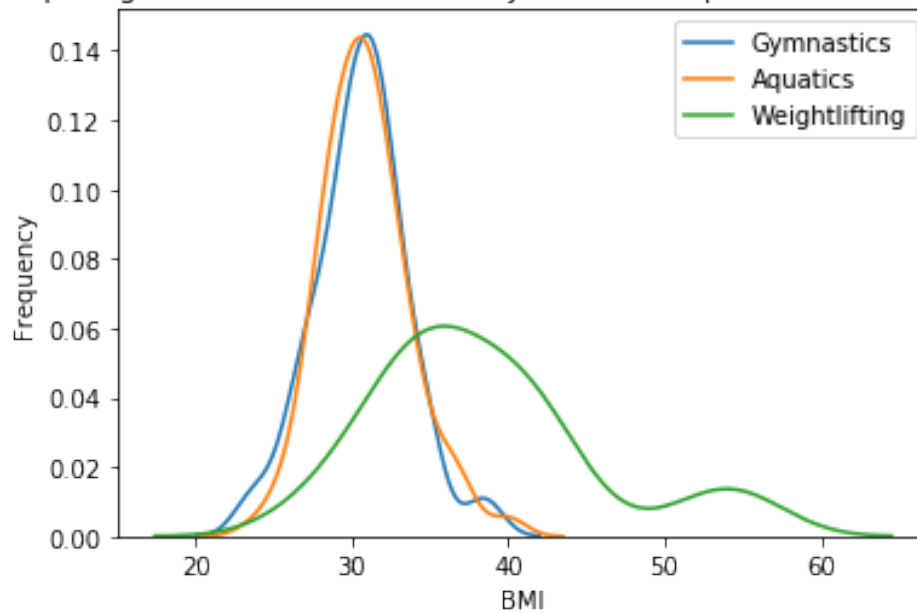
In [79]: *#pulls respective Series of aq/gy/wl athletes of their BMIs*

```

gy = physical[physical['sport']=='gymnastics']['BMI']
aq = physical[physical['sport']=='aquatics']['BMI']
wl = physical[physical['sport']=='weightlifting']['BMI']
sampleintgy = [random.randint(0, gy.shape[0]-1) for i in range(int(.1*gy.shape[0]))]
sampleintaq = [random.randint(0, aq.shape[0]-1) for i in range(int(.1*aq.shape[0]))]
sampleintwl = [random.randint(0, wl.shape[0]-1) for i in range(int(.1*wl.shape[0]))]
gy = gy.iloc[sampleintgy]
aq = aq.iloc[sampleintaq]
wl = wl.iloc[sampleintwl]
#density plot of BMI distribution
sns.distplot(gy, hist=False, label='Gymnastics')
sns.distplot(aq, hist=False, label='Aquatics')
sns.distplot(wl, hist=False, label='Weightlifting')
plt.xlabel('BMI')
plt.ylabel('Frequency')
plt.title("Comparing the BMI Distribution of Gymnastics, Aquatics, and Weightlifting")
plt.show()

```

Comparing the BMI Distribution of Gymnastics, Aquatics, and Weightlifting



```
In [80]: print("n1 =", len(sampleintgy))
         print("n2 =", len(sampleintaq))
         print("n3 =", len(sampleintwl))

n1 = len(sampleintgy)
n2 = len(sampleintaq)
n3 = len(sampleintwl)

gy_sum = sum(gy)
gy_sample_sq = gy**2
gy_sum_sq = sum(gy_sample_sq)
gy_avg = gy.mean()

aq_sum = sum(aq)
aq_sample_sq = aq**2
aq_sum_sq = sum(aq_sample_sq)
aq_avg = aq.mean()

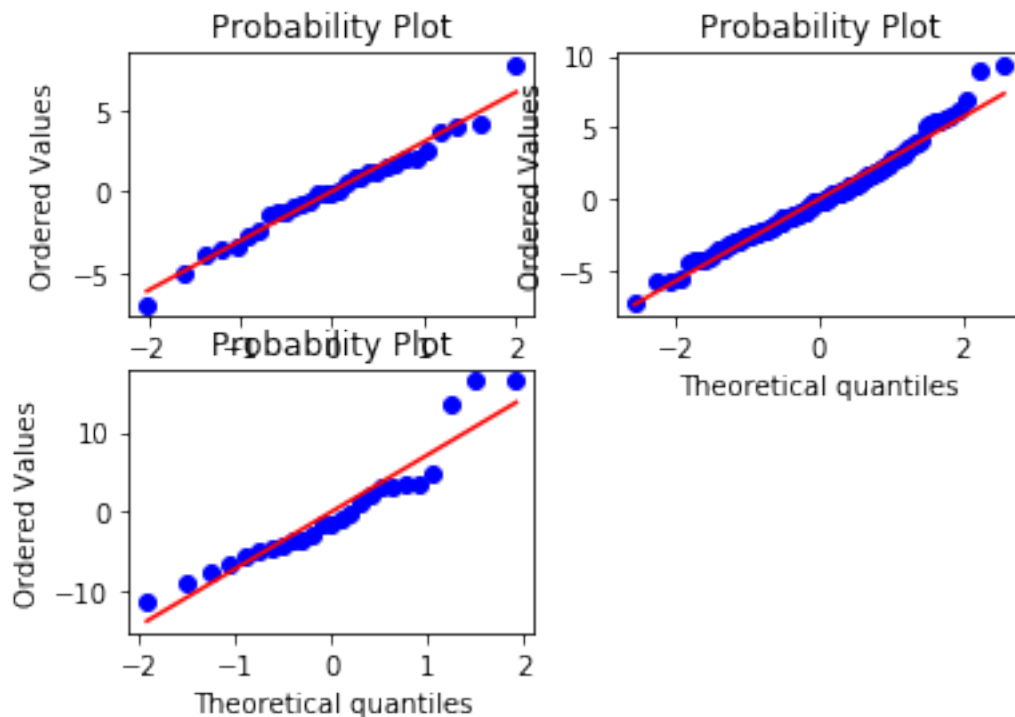
wl_sum = sum(wl)
wl_sample_sq = wl**2
wl_sum_sq = sum(wl_sample_sq)
wl_avg = wl.mean()

total_sum = gy_sum+aq_sum+wl_sum
```

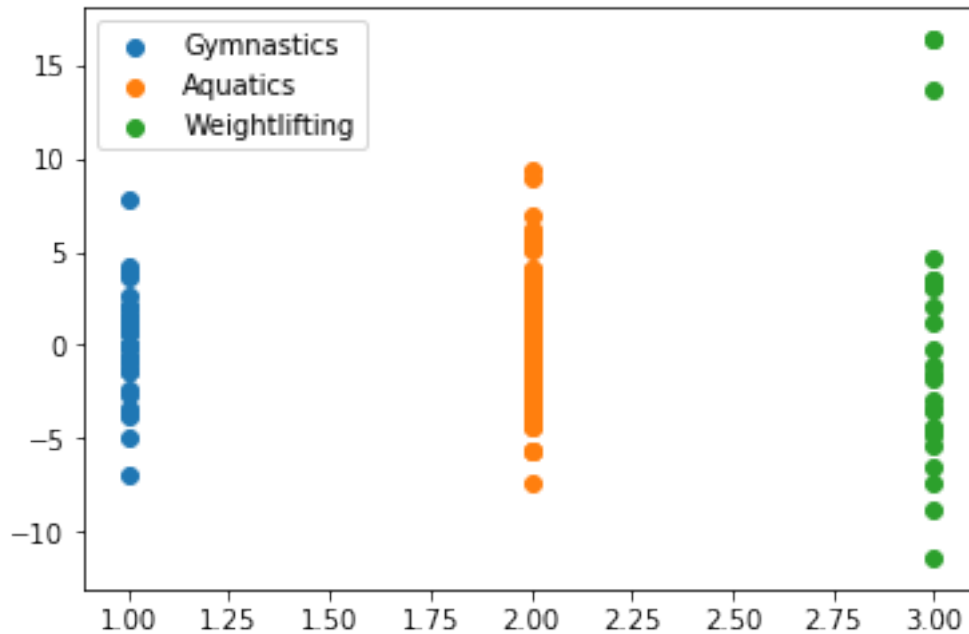
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n1 = 31
```

```
n2 = 139
n3 = 25
```

```
In [81]: gy_residuals = gy-gy_avg
aq_residuals = aq-aq_avg
wl_residuals = wl-wl_avg
ax1 = plt.subplot(221)
stats.probplot(gy_residuals, plot=plt)
ax2 = plt.subplot(222)
stats.probplot(aq_residuals, plot=plt)
ax3 = plt.subplot(223)
stats.probplot(wl_residuals, plot=plt)
plt.show()
```



```
In [82]: x = [1 for i in range(gy_residuals.shape[0])]
gym = plt.scatter(x, gy_residuals.values, label='Gymnastics')
x = [2 for i in range(aq_residuals.shape[0])]
aqu = plt.scatter(x, aq_residuals.values, label='Aquatics')
x = [3 for i in range(wl_residuals.shape[0])]
wei = plt.scatter(x, wl_residuals.values, label='Weightlifting')
plt.legend(handles=[gym, aqu, wei])
plt.show()
```



```
In [83]: ss_total = (gy_sum_sq+aq_sum_sq+wl_sum_sq) - ((total_sum)**2)/(n1+n2+n3)
print("SS_total =", ss_total)
ss_treat = ((gy_sum**2)/n1+(aq_sum**2)/n2+(wl_sum**2)/n3) - ((total_sum)**2)/(n1+n2+n3)
print("SS_treatments =", ss_treat)
ss_error = ss_total-ss_treat
print("SS_error =", ss_error)

ms_treat = ss_treat/2
print("MS_treatments =", ms_treat)
ms_error = ss_error/((n1+n2+n3)-2)
print("MS_error =", ms_error)
F0 = ms_treat/ms_error
print("Test statistic =", F0)

SS_total = 3903.76623784
SS_treatments = 1272.7589348
SS_error = 2631.00730304
MS_treatments = 636.379467401
MS_error = 13.6321621919
Test statistic = 46.6822106752

In [84]: print("Gymnastics Average BMI:", gy_avg)
print("Aquatics Average BMI:", aq_avg)
print("Weightlifting Average BMI:", wl_avg)
```

```

LSD_gyaq = 1.972*sqrt(ms_error*(1/n1+1/n2))
gyaq_diff = abs(gy_avg-aq_avg)
print("Mean difference of average BMI between Gymnastics and Aquatics is", gyaq_diff)
print("LSD of Gymnastics and Aquatics is", LSD_gyaq)

LSD_gywl = 1.972*sqrt(ms_error*(1/n1+1/n3))
gywl_diff = abs(gy_avg-wl_avg)
print("Mean difference of average BMI between Gymnastics and Weightlifting is", gywl_diff)
print("LSD of Gymnastics and Weightlifting is", LSD_gywl)

LSD_aqwl = 1.972*sqrt(ms_error*(1/n2+1/n3))
aqwl_diff = abs(aq_avg-wl_avg)
print("Mean difference of average BMI between Aquatics and Weightlifting is", aqwl_diff)
print("LSD of Aquatics and Weightlifting is", LSD_aqwl)

Gymnastics Average BMI: 30.6090364501
Aquatics Average BMI: 30.8733894514
Weightlifting Average BMI: 38.4616688617
Mean difference of average BMI between Gymnastics and Aquatics is 0.264353001303
LSD of Gymnastics and Aquatics is 1.4461904740385871
Mean difference of average BMI between Gymnastics and Weightlifting is 7.85263241152
LSD of Gymnastics and Weightlifting is 1.9571875530052536
Mean difference of average BMI between Aquatics and Weightlifting is 7.58827941022
LSD of Aquatics and Weightlifting is 1.5817352834614762

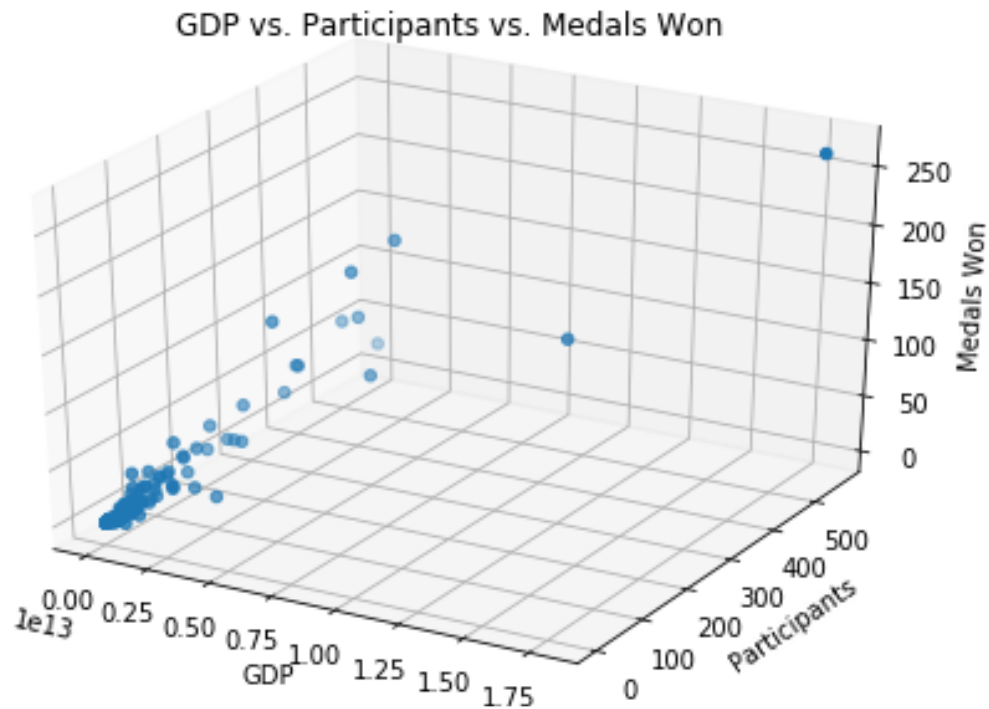
```

1.1 INVESTIGATION 2: Determining Relationship Between GDP, Participants, and Medals Won

```

In [179]: ath_data_copy = ath_data
country_data = pd.read_csv('countries.csv', index_col=0)
country_data['gdp']=country_data['gdp_per_capita']*country_data['population']
country_data = country_data.drop('gdp_per_capita', 1)
country_data = country_data.rename(index = str, columns={"code":"nationality"})
ath_data_copy = ath_data_copy.merge(country_data, on='nationality', how='left')
ath_data_copy = ath_data_copy.sort_values(by='gdp')
ath_data_copy = ath_data_copy[ath_data_copy.gdp.notnull()]
gdp_data = ath_data_copy.groupby(by="gdp")['totals'].agg(['count', 'sum'])
fig = plt.figure()
ax = Axes3D(fig)
ax.scatter(xs=gdp_data.index, ys= gdp_data['count'], zs=gdp_data['sum'], marker='o')
ax.set_xlabel('GDP')
ax.set_ylabel('Participants')
ax.set_zlabel('Medals Won')
plt.title("GDP vs. Participants vs. Medals Won")
plt.show()

```



```
In [215]: n = len(gdp_data.index.values)
          x1 = gdp_data.index.values.reshape(n,1)
          x2 = gdp_data['count'].values.reshape(n,1)
          ones = np.ones((n, 1), dtype=int)
          X = np.concatenate((ones, x1, x2), axis=1)
          y = gdp_data['sum'].values.reshape(n,1)

          txtxinv = np.linalg.inv(np.dot(X.T, X))
          b = np.dot(np.dot(txtxinv, X.T), y)
          print("B0 =", b[0][0])
          print("B1 =", b[1][0])
          print("B2 =", b[2][0])
          print("Fitted Linear Regression Model: medals_pred = ", round(b[0][0], 3), " + ", b[1][0],
                "*Participants", sep='')

          SSE = np.dot(y.T, y) - np.dot(np.dot(b.T, X.T), y)
          sigmasq = SSE/(n-3)
          print("sigmasq =", sigmasq[0][0])
          C = np.linalg.inv(np.dot(X.T, X))
          b1_lower = b[1][0] - 1.974*sqrt(sigmasq*C[1][1])
          b1_upper = b[1][0] + 1.974*sqrt(sigmasq*C[1][1])
          print("95% CI of B1 is [", b1_lower, ",", b1_upper, "].", sep='')
          b2_lower = b[2][0] - 1.974*sqrt(sigmasq*C[2][2])
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b2_upper = b[2][0]+1.974*sqrt(sigmasq*C[2][2])
print("95% CI of B2 is [",b2_lower, ",", b2_upper, "].", sep='')
print("Therefore, because 0 is not included in either confidence intervals, both features are statistically significant.")
SST = SSE + np.dot(np.dot(b.T, X.T), y)
print("R^2 = ", 1-(SSE/SST)[0][0])

fig = plt.figure(figsize=(20,15))
ax = fig.add_subplot(221, projection='3d')
xx, yy = np.meshgrid(range(0, int(2e13), int(1e11)), range(600))
z = b[0][0]+b[1][0]*xx+b[2][0]*yy
ax.plot_surface(xx, yy, z, color='cyan', rstride=10, cstride=10, shade=False)
ax.scatter(xs=gdp_data.index, ys= gdp_data['count'], zs=gdp_data['sum'], marker='o',
plt.title("Fitted Linear Regression Model")

ax2 = fig.add_subplot(222, projection='3d')
ax2.plot_surface(xx, yy, z, color='cyan', rstride=10, cstride=10, shade=False)
ax2.scatter(xs=gdp_data.index, ys= gdp_data['count'], zs=gdp_data['sum'], marker='o')
plt.title("Fitted Linear Regression Model")
ax2.view_init(azim=360)
plt.show()

```

B0 = -2.9481511314

B1 = 8.254217349e-12

B2 = 0.170736770254

Fitted Linear Regression Model: medals_pred = -2.948 + 8.254217349e-12*GDP + 0.171*Participants

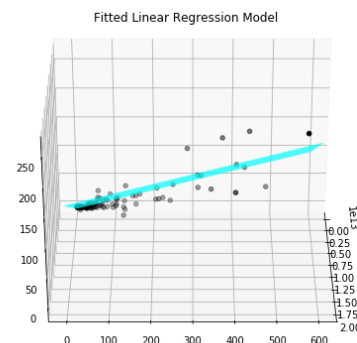
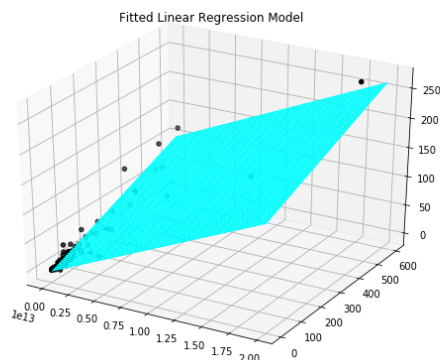
sigmasq = 134.695368088

95% CI of B1 is [6.84841639149e-12,9.66001830651e-12].

95% CI of B2 is [0.148252468415,0.193221072094].

Therefore, because 0 is not included in either confidence intervals, both features (GDP and number of participants) are statistically significant.

R^2 = 0.880472589569



```

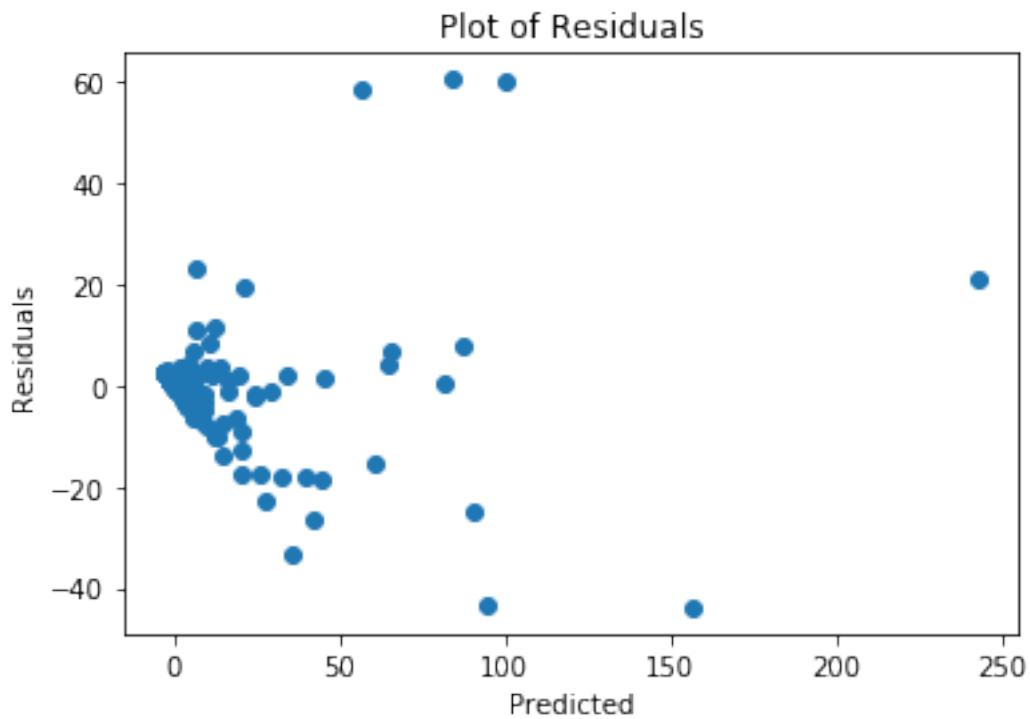
In [216]: yhat = b[0][0]+b[1][0]*x1+b[2][0]*x2
          residuals = y-yhat

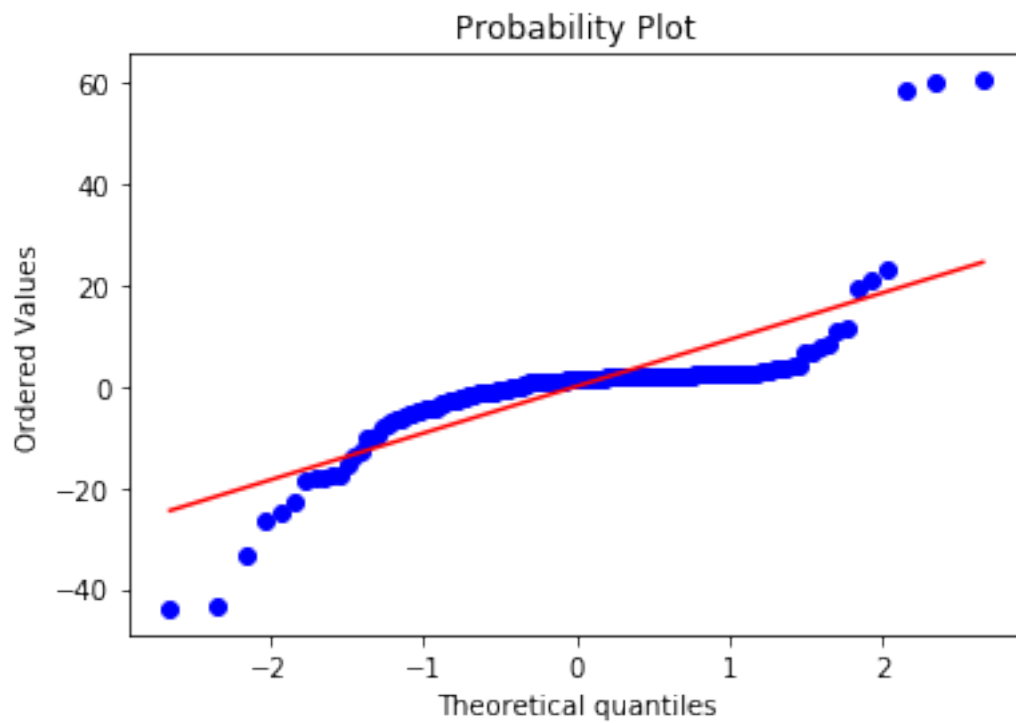
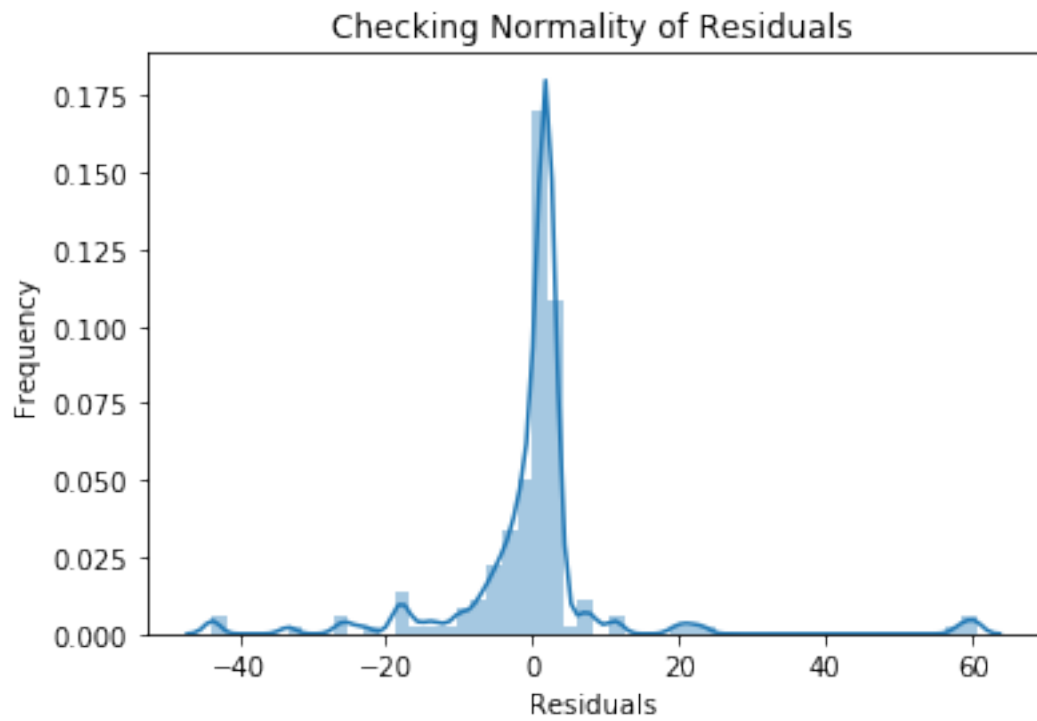
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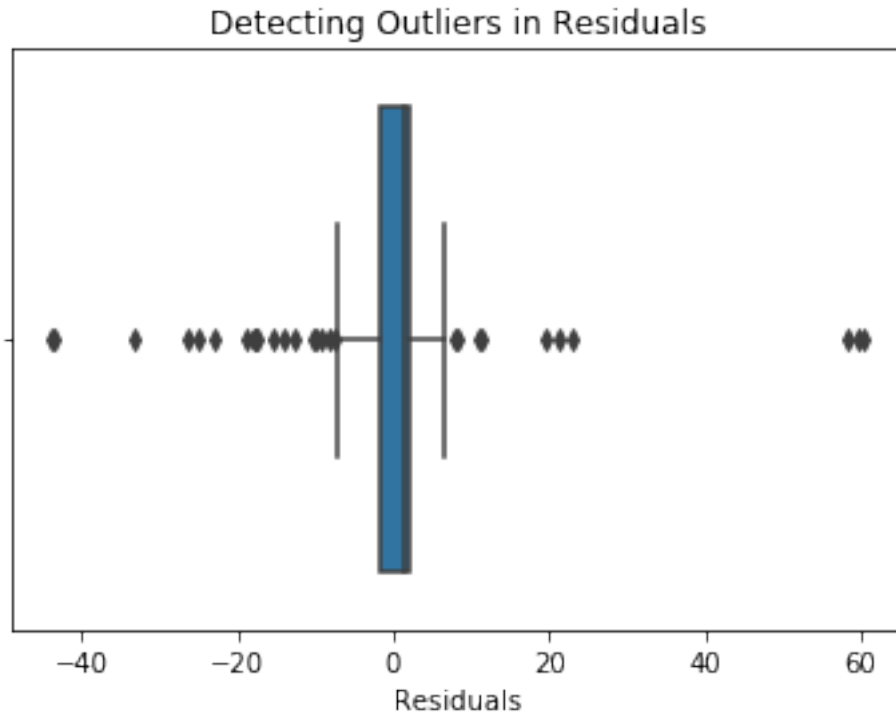
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plt.scatter(yhat, residuals)
plt.title("Plot of Residuals")
plt.xlabel('Predicted')
plt.ylabel('Residuals')
plt.show()
sns.distplot(residuals, hist=True)
plt.title("Checking Normality of Residuals")
plt.xlabel("Residuals")
plt.ylabel("Frequency")
plt.show()
stats.probplot(residuals.T[0], plot=plt)
plt.show()
sns.boxplot(residuals)
plt.title("Detecting Outliers in Residuals")
plt.xlabel('Residuals')
plt.show()

```







```
In [217]: y = y[~(residuals>5) & ~(residuals<-10)]
n=len(y)
y = y.reshape(n, 1)
x1 = x1[~(residuals>5) & ~(residuals<-10)].reshape(n,1)
x2 = x2[~(residuals>5) & ~(residuals<-10)].reshape(n,1)
z1 = (x2**3).reshape(n,1)
ones = np.ones((len(y), 1), dtype=int)
X = np.concatenate((ones, x1, x2, z1), axis=1)
xtxinv = np.linalg.inv(np.dot(X.T, X))
b = np.dot(np.dot(xtxinv, X.T), y)

for i in list(range(0,4)):
    print("B", i, " = ", b[i][0], sep='')

print("Fitted Polynomial Regression Model: medals_pred = ", round(b[0][0], 3), " + ",
      "*Participants + ", b[3][0], "*Participants^3", sep='')

yhat = b[0][0]+b[1][0]*x1+b[2][0]*x2+b[3][0]*z1
residuals = y-yhat

SSE = np.dot(y.T, y)-np.dot(np.dot(b.T, X.T), y)
sigmasq = SSE/(n-3)
print("sigmasq =", sigmasq[0][0])
C = np.linalg.inv(np.dot(X.T, X))
```

```

for i in list(range(1,4)):
    b_lower = b[i][0]-1.977*sqrt(sigmasq*C[i][i])
    b_upper = b[i][0]+1.977*sqrt(sigmasq*C[i][i])
    print("95% CI of B", i, " is [", b_lower, ",", b_upper, "].", sep='')

print("Therefore, because 0 is not included in any confidence intervals, all features are statistical")

fig = plt.figure(figsize=(20,15))
ax = fig.add_subplot(221, projection='3d')
xx, yy = np.meshgrid(range(0, int(3e12), int(1e11)), range(500))
z = b[0][0]+b[1][0]*xx+b[2][0]*yy+b[3][0]*(yy**3)
ax.plot_surface(xx, yy, z, color='cyan', shade=False)
plt.title("Fitted Linear Regression Model")
ax.scatter(xs=x1, ys= x2, zs=y, marker='o', color='black')

ax2 = fig.add_subplot(222, projection='3d')
ax2.plot_surface(xx, yy, z, color='cyan', shade=False)
ax2.scatter(xs=x1, ys= x2, zs=y, marker='o', color='black')
plt.title("Fitted Linear Regression Model")
ax2.view_init(azim=360)
plt.show()

```

B0 = -1.69714550936

B1 = 3.69931707676e-12

B2 = 0.149460048144

B3 = 2.41768698958e-07

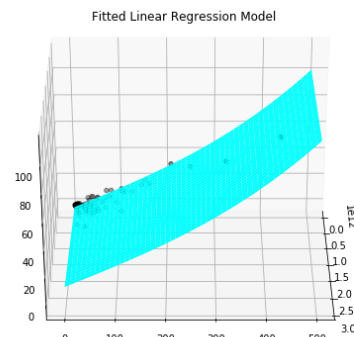
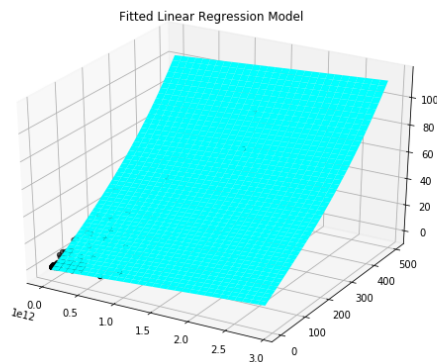
Fitted Polynomial Regression Model: medals_pred = -1.697 + 3.69931707676e-12*GDP + 0.149*Participation
sigmasq = 5.86699973489

95% CI of B1 is [7.767010926e-13,6.62193306092e-12].

95% CI of B2 is [0.135815345994,0.163104750294].

95% CI of B3 is [1.47978077257e-07,3.35559320659e-07].

Therefore, because 0 is not included in any confidence intervals, all features are statistical.



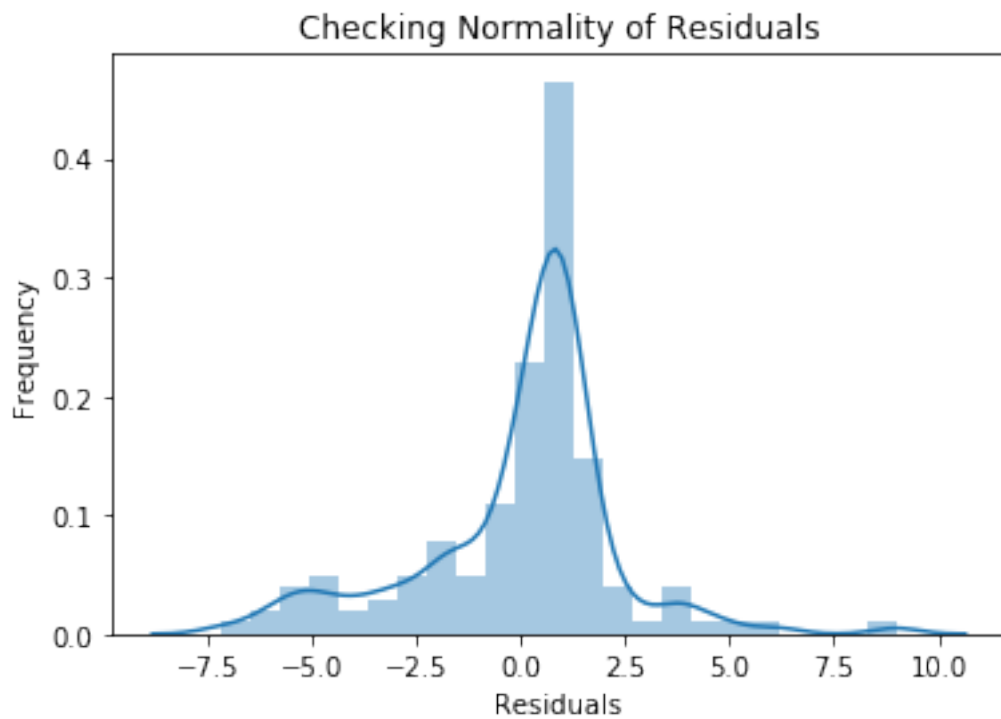
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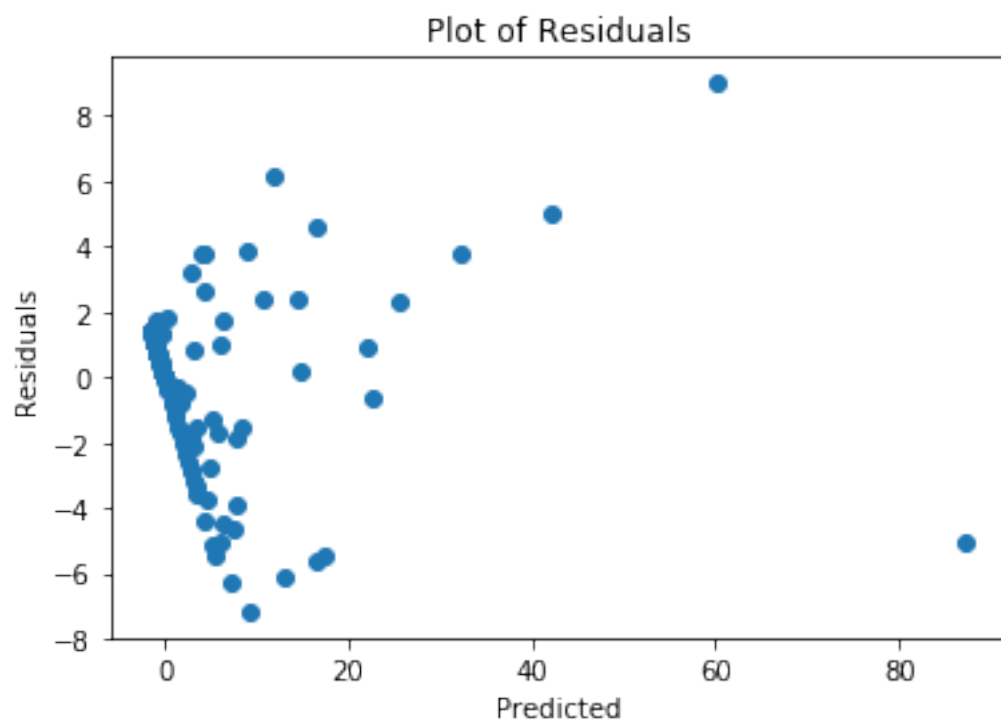
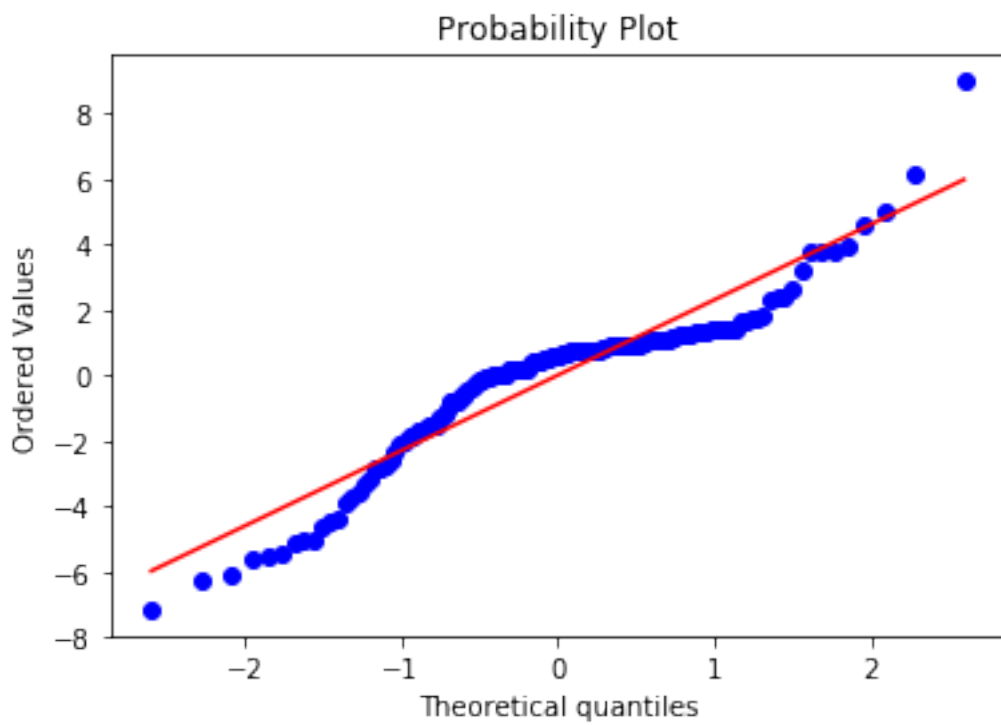
In [218]: sns.distplot(residuals, hist=True)
plt.title("Checking Normality of Residuals")
plt.xlabel("Residuals")
plt.ylabel("Frequency")
plt.show()
stats.probplot(residuals.T[0], plot=plt)
plt.show()

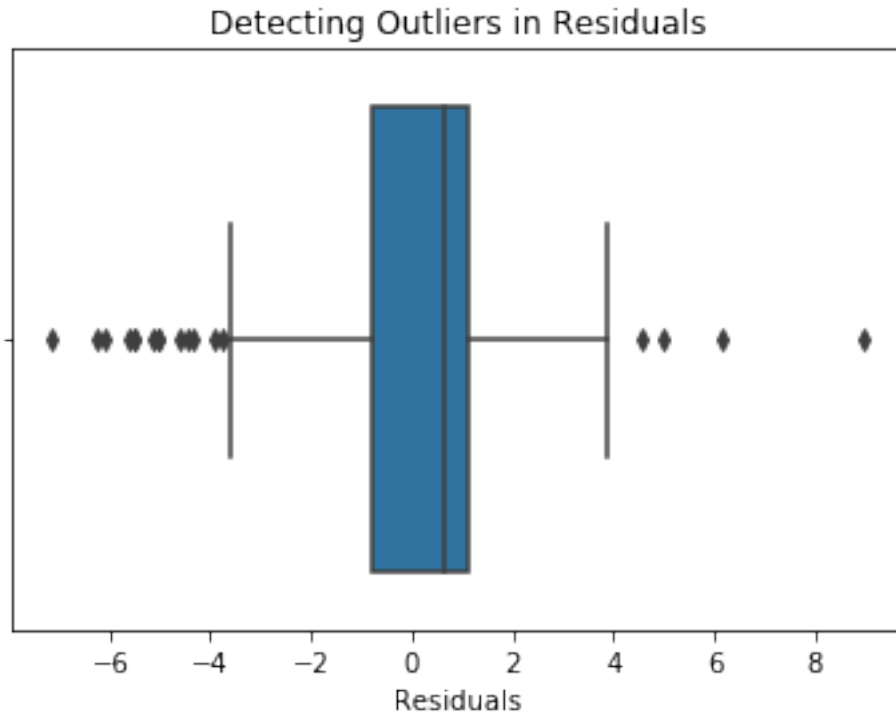
plt.scatter(yhat, residuals)
plt.title("Plot of Residuals")
plt.xlabel('Predicted')
plt.ylabel('Residuals')
plt.show()

sns.boxplot(residuals)
plt.title("Detecting Outliers in Residuals")
plt.xlabel('Residuals')
plt.show()

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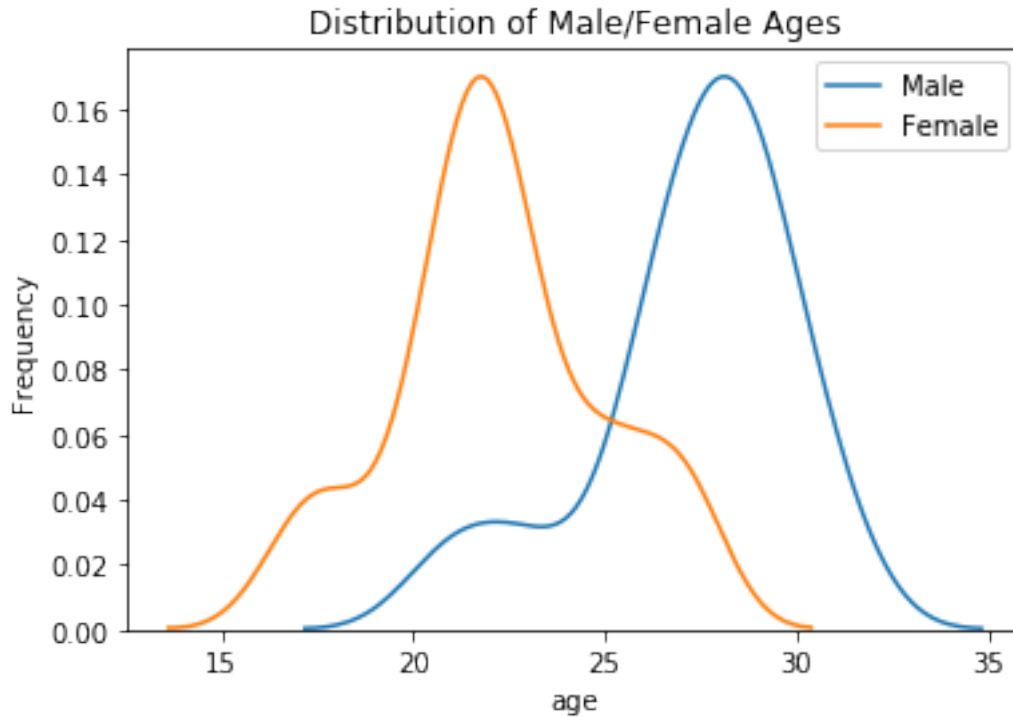






2 INVESTIGATION 3: Comparing Mean Age of Male/Female Medalists in Gymnastics

```
In [222]: gymnastics = ath_data[ath_data['sport']=='gymnastics']
gymnastics_m = gymnastics[gymnastics['sex']=='male']
gymnastics_f = gymnastics[gymnastics['sex']=='female']
sampleintgy_m = [random.randint(0, gymnastics_m.shape[0]-1) for i in
                  range(int(.5*gymnastics_m.shape[0]))]
sampleintgy_f = [random.randint(0, gymnastics_f.shape[0]-1) for i in
                  range(int(.5*gymnastics_f.shape[0]))]
gymnastics_m = gymnastics_m.iloc[sampleintgy_m]
gymnastics_f = gymnastics_f.iloc[sampleintgy_f]
gymnastics_winners_m = gymnastics_m[gymnastics_m['totals']>0]['age']
gymnastics_winners_f = gymnastics_f[gymnastics_f['totals']>0]['age']
sns.distplot(gymnastics_winners_m, hist=False, label='Male')
sns.distplot(gymnastics_winners_f, hist=False, label='Female')
plt.title("Distribution of Male/Female Ages")
plt.ylabel('Frequency')
plt.show()
```

```
In [223]: gymnastics = ath_data[ath_data['sport']=='gymnastics']
gymnastics_m = gymnastics[gymnastics['sex']=='male']
gymnastics_f = gymnastics[gymnastics['sex']=='female']
sampleintgy_m = [random.randint(0, gymnastics_m.shape[0]-1) for i in
                  range(int(.5*gymnastics_m.shape[0]))]
sampleintgy_f = [random.randint(0, gymnastics_f.shape[0]-1) for i in
                  range(int(.5*gymnastics_f.shape[0]))]
gymnastics_m = gymnastics_m.iloc[sampleintgy_m]
gymnastics_f = gymnastics_f.iloc[sampleintgy_f]
gymnastics_winners_m = gymnastics_m[gymnastics_m['totals']>0]['age']
gymnastics_winners_f = gymnastics_f[gymnastics_f['totals']>0]['age']
print("Average age of male gymnastics medalists:", gymnastics_winners_m.mean())
print("Average age of female gymnastics medalists:", gymnastics_winners_f.mean())
print("Standard deviation of ages of male gymnastics medalists:", gymnastics_winners_m.std())
print("Standard deviation of ages of female gymnastics medalists:", gymnastics_winners_f.std())
print("n_male =", gymnastics_winners_m.shape[0])
print("n_female =", gymnastics_winners_f.shape[0])
```

Average age of male gymnastics medalists: 25.5454545455

Average age of female gymnastics medalists: 21.85

Standard deviation of ages of male gymnastics medalists: 2.65945995885

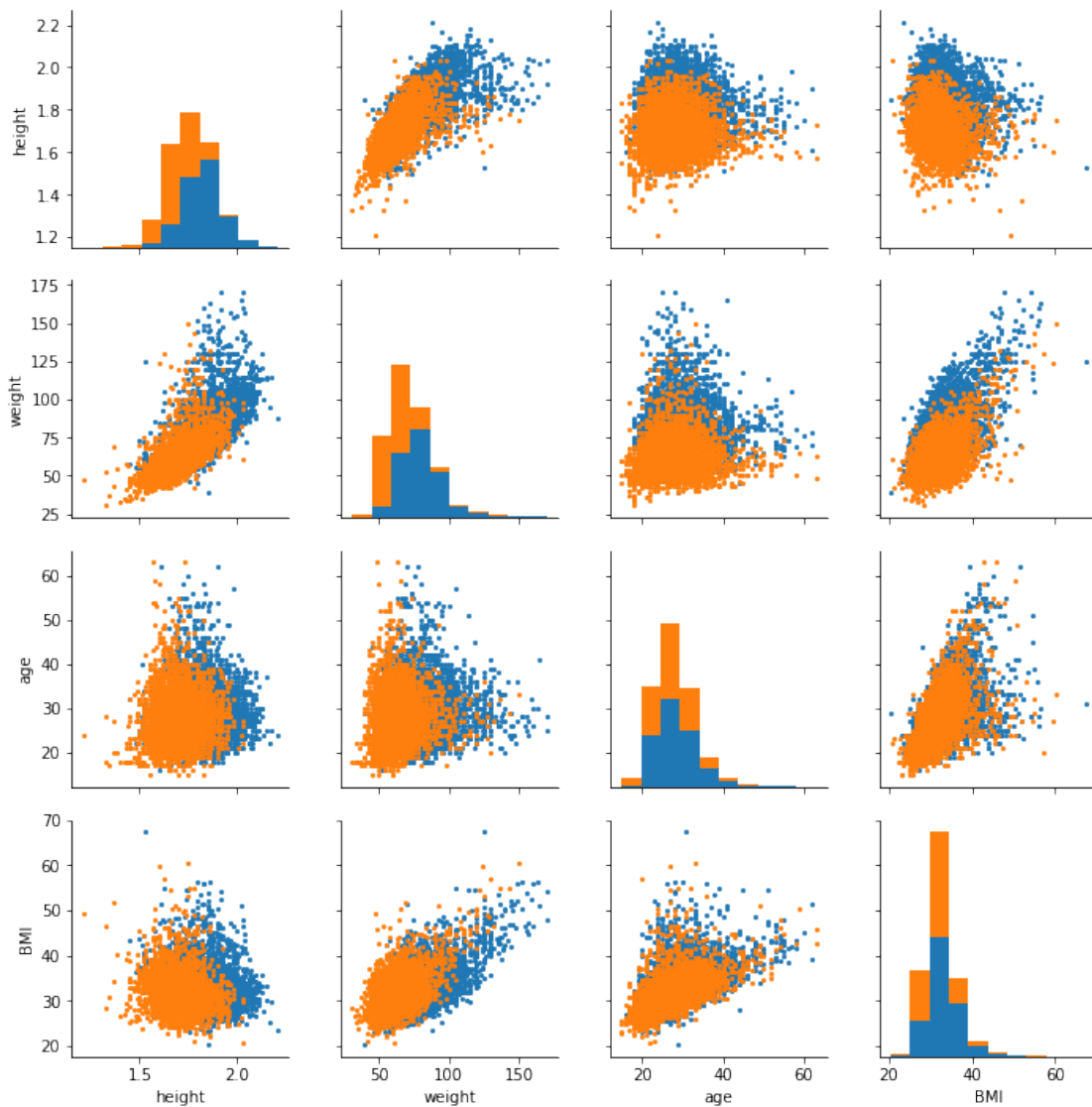
Standard deviation of ages of female gymnastics medalists: 3.54334067765

n_male = 11

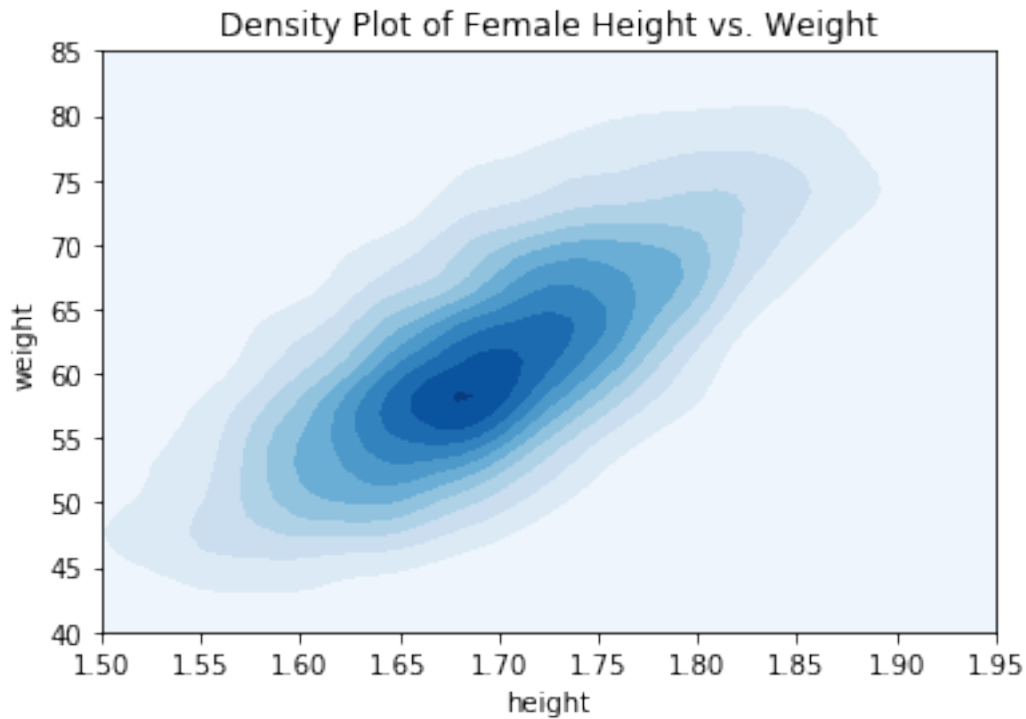
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n_female = 20
```

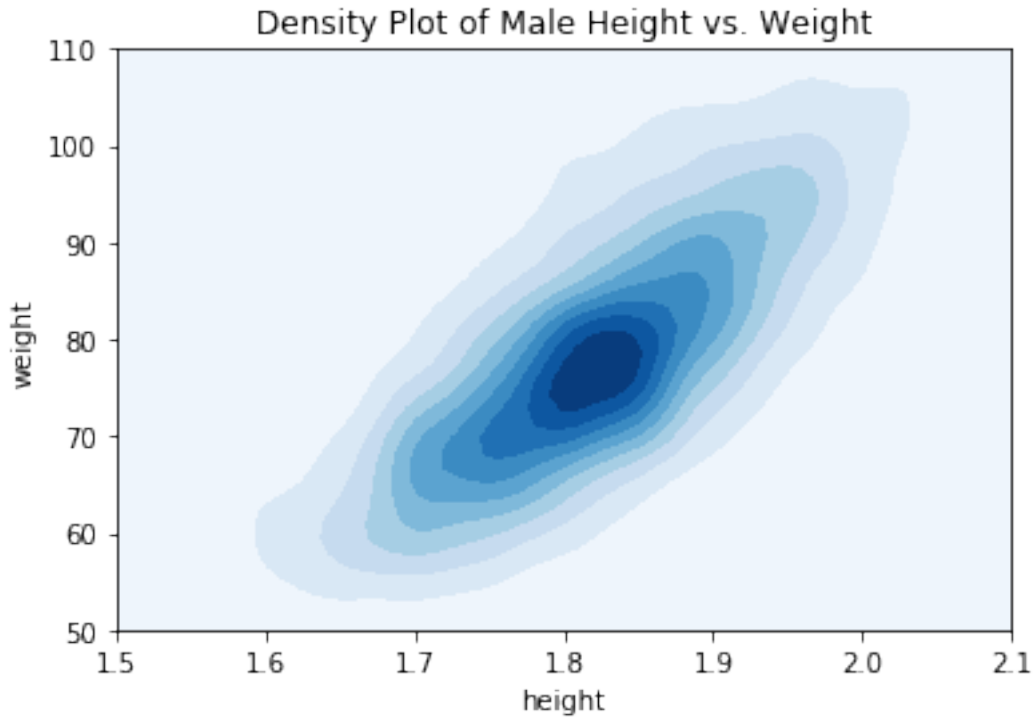
3 INVESTIGATION 4: Analyzing Heights/Weights Between Male/Female Athletes

```
In [88]: #pulls the height/weight/age/sex of athletes; removes athletes with NaN  
#values in any height/weight columns  
#plots a scatterplot matrix to observe relationship between features  
plot = sns.PairGrid(physical, hue='sex')  
plot = plot.map_diag(plt.hist)  
plot = plot.map_offdiag(plt.scatter, s = 4)  
#sns.pairplot(physical)  
plt.show()
```



```
In [89]: #plots density plot of female/male height vs. weight
physical_f=physical[physical['sex']=='female']
physical_m=physical[physical['sex']=='male']
sns.kdeplot(physical_f.height, physical_f.weight, cmap="Blues", shade=True)
plt.xlim(1.5, 1.95)
plt.ylim(40, 85)
plt.title('Density Plot of Female Height vs. Weight')
plt.show()
sns.kdeplot(physical_m.height, physical_m.weight, cmap="Blues", shade=True)
plt.xlim(1.5, 2.1)
plt.title('Density Plot of Male Height vs. Weight')
plt.ylim(50,110)
plt.show()
```





```
In [138]: male = physical[physical['sex']=='male']
female = physical[physical['sex']=='female']
sampleint_m = [random.randint(0, male.shape[0]-1) for i in
                range(int(.5*male.shape[0]))]
sampleint_f = [random.randint(0, female.shape[0]-1) for i in
                range(int(.5*female.shape[0]))]
male = male.iloc[sampleint_m]
female = female.iloc[sampleint_f]
print("num_males = ", len(sampleint_m))
print("num_females = ", len(sampleint_f))
print("Male average height is ", male['height'].mean())
print("Female average height is ", female['height'].mean())
print("Male height standard deviation is ", male['height'].std())
print("Female height standard deviation is ", female['height'].std())
```

```
num_males = 2931
num_females = 2498
Male average height is 1.82363357216
Female average height is 1.69742994396
Male height standard deviation is 0.102126874276
Female height standard deviation is 0.0879301891154
```

```
In [139]: print("Male average weight is ", male['weight'].mean())
          print("Female average weight is ", female['weight'].mean())
```

```
print("Male weight standard deviation is ", male['weight'].std())
print("Female weight standard deviation is ", female['weight'].std())
```

Male average weight is 79.9099283521

Female average weight is 62.5940752602

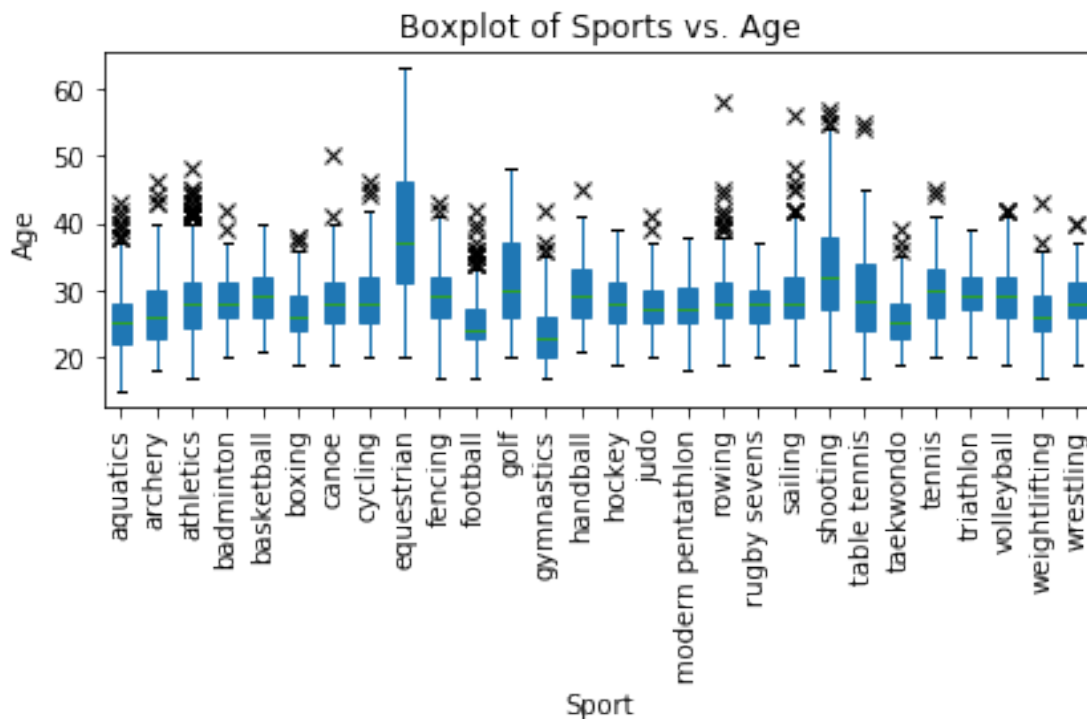
Male weight standard deviation is 15.646524449

Female weight standard deviation is 11.5126715776

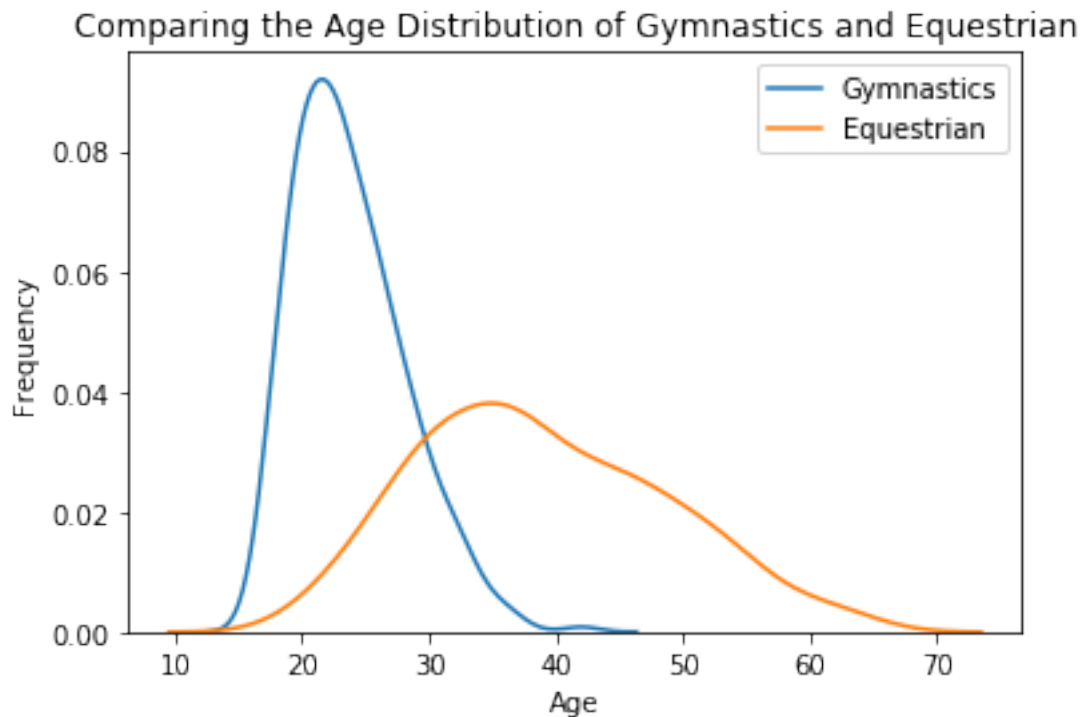
4 INVESTIGATION 5: Comparing Variability of Ages of Equestrians and Gymnasts

```
In [52]: plot = ath_data.boxplot(column='age', by='sport', patch_artist=True,
    flierprops=dict(marker='x', color='cyan'))
plot.grid(False)
plot.set_xlabel('Sport')
plot.set_ylabel('Age')
plt.title("Boxplot of Sports vs. Age")

plt.suptitle("")
plt.xticks(rotation=90)
plt.tight_layout()
plt.show()
```



```
In [53]: #pulls respective Series of the equestrian/gymnastics athletes of their ages
gymnastics_age = gymnastics['age']
equestrian = ath_data[ath_data['sport']=='equestrian']
equestrian_age = equestrian['age']
#density plot of the age distribution
sns.distplot(gymnastics_age, hist=False, label='Gymnastics')
sns.distplot(equestrian_age, hist=False, label='Equestrian')
plt.title("Comparing the Age Distribution of Gymnastics and Equestrian")
plt.xlabel('Age')
plt.ylabel('Frequency')
plt.show()
```



```
In [54]: gymnastics_age = gymnastics['age']
equestrian = ath_data[ath_data['sport']=='equestrian']
equestrian_age = equestrian['age']
sampleint_gy = [random.randint(0, gymnastics_age.shape[0]-1) for i in
                 range(int(.5*gymnastics_age.shape[0]))]
sampleint_eq = [random.randint(0, equestrian_age.shape[0]-1) for i in
                 range(int(.5*equestrian_age.shape[0]))]
gymnastics_age = gymnastics_age.iloc[sampleint_gy]
equestrian_age = equestrian_age.iloc[sampleint_eq]

print("n_gymnasts =", gymnastics_age.shape[0])
print("n_equestrians =", equestrian_age.shape[0])
```

```

print("Mean of gymnast ages is", gymnastics_age.mean())
print("Mean of equestrian ages is", equestrian_age.mean())
print("Standard deviation of gymnast ages is", gymnastics_age.std())
print("Standard deviation of equestrian ages is", equestrian_age.std())

```

```

n_gymnasts = 162
n_equestrians = 111
Mean of gymnast ages is 23.5432098765
Mean of equestrian ages is 39.4234234234
Standard deviation of gymnast ages is 4.24424896301
Standard deviation of equestrian ages is 9.57415987252

```

```

In [63]: data = gymnastics.append(equestrian)
sample_gym = [random.randint(0, gymnastics.shape[0]) for i in
               range(int(.8*gymnastics.shape[0]))]
sample_test_gym = []
for i in list(range(gymnastics.shape[0])):
    if i not in sample_gym:
        sample_test_gym.append(i)
train = data.iloc[sample_gym]
ones = [1 for i in range(train.shape[0])]
train['label'] = ones
test = data.iloc[sample_test_gym]
n1 = len(sample_test_gym)
sample_eq = [gymnastics.shape[0]-1+random.randint(0, equestrian.shape[0]) for i in
              range(int(.8*equestrian.shape[0]))]
sample_test_eq = []
list_range = list(range(gymnastics.shape[0]-1, gymnastics.shape[0]-1+equestrian.shape[0]))
for i in list_range:
    if i not in sample_eq:
        sample_test_eq.append(i)
eq_train = data.iloc[sample_eq]
zeros = [0 for i in range(eq_train.shape[0])]
eq_train['label']=zeros
train = train.append(eq_train)
eq_test = data.iloc[sample_test_eq]
test = test.append(eq_test)

param_grid = {'C': [1, 5, 10, 50], 'kernel': ['linear']},
grid = GridSearchCV(SVC(), param_grid, cv=5, scoring='accuracy')
grid.fit(train['age'].values.reshape(-1,1), train['label'])
print("Best values of the parameters for the SVM are", grid.best_params_, "with an accuracy of", grid.best_score_)
predict = grid.predict(test['age'].values.reshape(-1,1))

h = 0.2
x_min, x_max = min(test['age']) - 1, max(test['age']) + 1
y_min, y_max = 0, 2

```

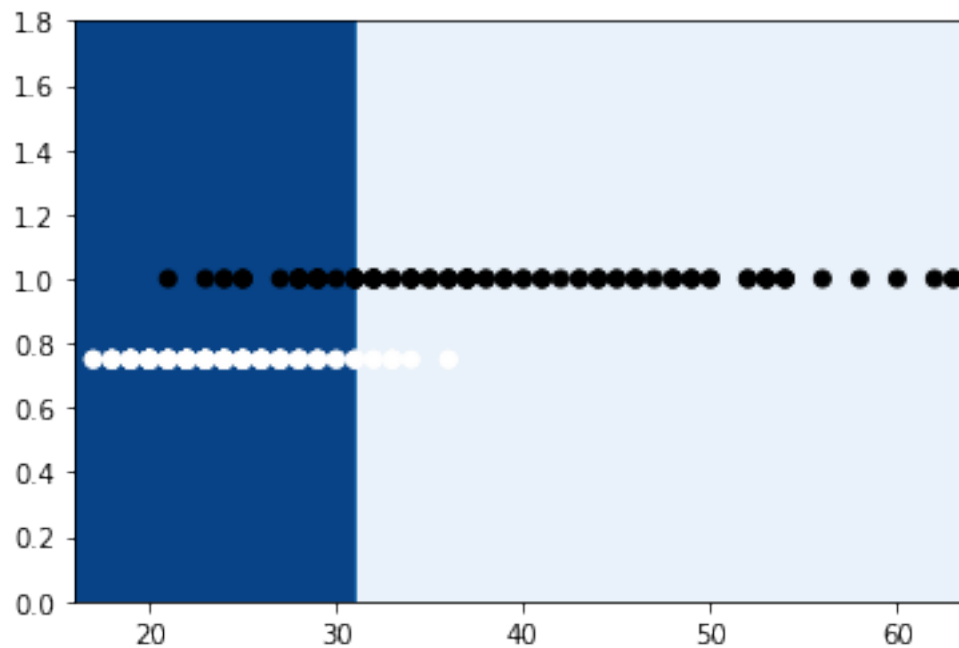
```

xx, yy = np.meshgrid(
    np.arange(x_min, x_max, h),
    np.arange(y_min, y_max, h))

Z = grid.predict(np.c_[xx.ravel()])
Z = Z.reshape(xx.shape)
plt.contourf(xx, yy, Z, cmap="Blues")
ones = [1 for i in range(test.shape[0])]
color= ['black' if l == 'equestrian' else 'white' for l in test['sport']]
vec = []
for i in list(range(test.shape[0])):
    if test['sport'].iloc[i]=='gymnastics':
        vec.append(0.75)
    else:
        vec.append(1)
plt.scatter(test['age'].values, vec, c=color, cmap=plt.cm.Paired)
plt.figure
plt.show()

```

Best values of the parameters for the SVM are {'C': 10, 'kernel': 'linear'} with an accuracy of 0.95.



5 INVESTIGATION 6: Comparing Proportion of Male and Female Medalists

```
In [56]: males = ath_data[ath_data['sex']=='male']
         females = ath_data[ath_data['sex']=='female']
         sampleint_m = [random.randint(0, males.shape[0]-1) for i in
                        range(int(.5*males.shape[0]))]
         sampleint_f = [random.randint(0, females.shape[0]-1) for i in
                        range(int(.5*females.shape[0]))]
         males = males.iloc[sampleint_m]
         females = females.iloc[sampleint_f]
         male_winners = males[males['totals']>0]
         female_winners = females[females['totals']>0]
         print("n_males =", males.shape[0])
         print("n_females =", females.shape[0])
         print("Proportion of male medalists:", male_winners.shape[0]/males.shape[0])
         print("Proportion of female medalists:", female_winners.shape[0]/females.shape[0])

n_males = 3166
n_females = 2602
Proportion of male medalists: 0.15476942514213518
Proportion of female medalists: 0.16986933128362797
```