# Data Science Research : The PAMAP2 Physical Activity Monitoring Dataset

## Introduction

In this report, we strive to devise software and hardware that can determine the amount of physical activity a person performs and provide insights gleaned from the data.

The PAMAP2 Physical Activity Monitoring Dataset contains the data carried out on 9 subjects which include an adult group of 8 males and 1 female and their corresponding readings were taken by wearing three different Inertial Measurements Units and Heart Rate monitor. There were 18 different physical activities(running,rope jumping, lying etc) performed on each subject, and their hand, chest, and ankle readings were recorded. The readings of individual subjects are stored in .dat files. This text file contains 54 different attributes (including timestamps, activity IDs, heart rates, and IMU sensory data). Analyses are carried out in various stages, such as exploratory data analysis, hypothesis testing, and modeling.

## Content

### Preparatory Task

- Importing libraries

### Data Cleaning:

Functions involved:-

- Cleaning the data by removing the null values and the variables that are not used in this analysis using data_cleaning()
- Sub-Function :fill_null_heartrate() :- replace Null values of heart rate column

### Exploratory Data Analysis:

- Generation of test and train data
- Activity time analysis by subjectID
- Analysis on activity by heartrate
- Analysis on activity by calorie burnt
- Analysis on activity by heart, chest and ankle temperature
- Correlation analysis

### Hypothesis Testing:

- Hypothesis stated : A hypothesis of dependency between activity and human heartrate fluctiations.

- Perform z-test
- Result based on z-test

### Modelling :

- Polynomial Regression
- Random Forest algorithm

## Preparatory Task

In this process, the libraries that are needed are imported, as well as the files that need to be loaded.

```
#standard imports for when working with pandas
import numpy as np
#matplotlib inline
from matplotlib import pyplot as plt
from scipy import stats
import math
import pandas as pd
import seaborn as sns
from pandas.plotting import scatter_matrix
pd.options.mode.chained_assignment = None
from sklearn.model_selection import train_test_split

subjectID = [1,2,3,4,5,6,7,8,9]

activityIDdict = {0: 'transient',
              1: 'lying',
              2: 'sitting',
              3: 'standing',
              4: 'walking',
              5: 'running',
              6: 'cycling',
              7: 'Nordic_walking',
              9: 'watching_TV',
              10: 'computer_work',
              11: 'car driving',
              12: 'ascending_stairs',
              13: 'descending_stairs',
              16: 'vacuum_cleaning',
              17: 'ironing',
              18: 'folding_laundry',
              19: 'house_cleaning',
              20: 'playing_soccer',
              24: 'rope_jumping' }

#weight of the subjects
subject_weights={1:83,2:78,3:92,4:95,5:73,6:69,7:86,8:87,9:65}
```

```
#the metabolic equivalent of the activity, which is a measure of the
intensity of the activity
MET_values = {1: 1,
              2: 1.8,
              3: 1.8,
              4: 3.5,
              5: 7.5,
              6: 4,
              7: 5.5,
              12:8,
              13: 3,
              16: 3.5,
              17: 2.3,
              24: 9}

List_of_Subjects=['Dataset/Protocol/subject101.dat',
                  'Dataset/Protocol/subject102.dat',
                  'Dataset/Protocol/subject103.dat',
                  'Dataset/Protocol/subject104.dat',
                  'Dataset/Protocol/subject105.dat',
                  'Dataset/Protocol/subject106.dat',
                  'Dataset/Protocol/subject107.dat',
                  'Dataset/Protocol/subject108.dat',
                  'Dataset/Protocol/subject109.dat']

IMUhand = ['Temperature_hand',
           '3D_hand_Accl_16_1', '3D_hand_Accl_16_2',
'3D_hand_Accl_16_3',
           '3D_hand_Accl_6_1', '3D_hand_Accl_6_2', '3D_hand_Accl_6_3',

           '3D_handGyro_1', '3D_handGyro_2', '3D_handGyro_3',
           '3D_handmagneto_1', '3D_handmagneto_2', '3D_handmagneto_3',
           'Orientation_hand_1', 'Orientation_hand_2',
'Orientation_hand_3', 'Orientation_hand_4']

IMUchest = ['Temperature_chest',
           '3D_chest_Accl_16_1', '3D_chest_Accl_16_2',
'3D_chest_Accl_16_3',
           '3D_chest_Accl_6_1', '3D_chest_Accl_6_2',
'3D_chest_Accl_6_3',
           '3D_chestGyro_1', '3D_chestGyro_2', '3D_chestGyro_3',
           '3D_chestmagneto_1', '3D_chestmagneto_2',
'3D_chestmagneto_3',
           'Orientation_chest_1', 'Orientation_chest_2',
'Orientation_chest_3', 'Orientation_chest_4']

IMUankle = ['Temperature_ankle',
           '3D_ankle_Accl_16_1', '3D_ankle_Accl_16_2',
'3D_ankle_Accl_16_3',
```

```
           '3D_ankle_Accl_6_1', '3D_ankle_Accl_6_2',
'3D_ankle_Accl_6_3',
           '3D_ankleGyro_1', '3D_ankleGyro_2', '3D_ankleGyro_3',
           '3D_anklemagneto_1', '3D_anklemagneto_2',
'3D_anklemagneto_3',
           'Orientation_ankle_1', 'Orientation_ankle_2',
'Orientation_ankle_3', 'Orientation_ankle_4']

columns=["timestamp", "activityID","heartrate"]
+IMUhand+IMUchest+IMUankle

len(columns)
```

```
54
```

To read and load the .dat file into a single dataframe, a list of subjects (List_of_Subjects) is created. We create a dictionary activityIDdict that maps each activityId to its associated activity name for later processing steps. Following that, a list of hand, chest, and ankle inertial measurement units (IMU) is created so that column names can be assigned to the obtained dataframe. In total, 54 IMU will be present in the dataframe, which means 54 columns.

```
def create_dataframe(list_of_files):
    datafr = pd.DataFrame()
    for file in list_of_files:
        #procData = pd.read_table(file, header=None, sep='\s+')
        df = pd.read_csv(file,sep='\s+|\s+',engine='python')
        strfile=file[17:27]+'.csv'
        df.to_csv(strfile, index=None)
        phydf=pd.read_csv(strfile)
        phydf.columns = columns
        phydf['subject_id'] = int(file[-5])
        #dataCollection = dataCollection.append(procData,
ignore_index=True)
        datafr=pd.concat([datafr, phydf], ignore_index=True)
    return datafr

datafr=create_dataframe(List_of_Subjects)
#dataCollection.reset_index(drop=True, inplace=True)
datafr.reset_index(drop=True, inplace=True)
#dataCollection.head()
datafr.head(10)
```

```
   timestamp  activityID  heartrate  Temperature_hand
3D_hand_Accl_16_1  \
0       8.39           0        NaN              30.0
2.18837
1       8.40           0        NaN              30.0
2.37357
2       8.41           0        NaN              30.0
```

```
2.07473
3       8.42           0        NaN              30.0
2.22936
4       8.43           0        NaN              30.0
2.29959
5       8.44           0        NaN              30.0
2.33738
6       8.45           0        NaN              30.0
2.37142
7       8.46           0        NaN              30.0
2.33951
8       8.47           0        NaN              30.0
2.25966
9       8.48           0      104.0              30.0
2.29745

   3D_hand_Accl_16_2  3D_hand_Accl_16_3  3D_hand_Accl_6_1
3D_hand_Accl_6_2  \
0            8.56560            3.66179           2.39494
8.55081
1            8.60107            3.54898           2.30514
8.53644
2            8.52853            3.66021           2.33528
8.53622
3            8.83122            3.70000           2.23055
8.59741
4            8.82929            3.54710           2.26132
8.65762
5            8.82900            3.54767           2.27703
8.77828
6            9.05500            3.39347           2.39786
8.89814
7            9.13251            3.54668           2.44371
8.98841
8            9.09415            3.43015           2.42877
9.01871
9            8.90450            3.46984           2.39736
8.94335

   3D_hand_Accl_6_3  ...  3D_ankleGyro_2  3D_ankleGyro_3
3D_anklemagneto_1  \
0           3.64207  ...       -0.004638        0.000368           -
59.8479
1           3.73280  ...        0.000148        0.022495           -
60.7361
2           3.73277  ...       -0.020301        0.011275           -
60.4091
3           3.76295  ...       -0.014303       -0.002823           -
61.5199
4           3.77788  ...       -0.016024        0.001050           -
```

```
60.2954
5          3.73230  ...      -0.053934       0.015594          -
60.6307
6          3.64131  ...      -0.039937      -0.000785          -
60.5171
7          3.62596  ...      -0.010042       0.017701          -
61.2916
8          3.61081  ...      -0.013923       0.014498          -
60.8509
9          3.53551  ...       0.002283       0.020352          -
61.5302

   3D_anklemagneto_2  3D_anklemagneto_3  Orientation_ankle_1  \
0           -38.8919           -58.5253                  1.0
1           -39.4138           -58.3999                  1.0
2           -38.7635           -58.3956                  1.0
3           -39.3879           -58.2694                  1.0
4           -38.8778           -58.3977                  1.0
5           -38.8676           -58.2711                  1.0
6           -38.9819           -58.2733                  1.0
7           -39.6182           -58.1499                  1.0
8           -39.0821           -58.1478                  1.0
9           -38.7240           -58.3860                  1.0

   Orientation_ankle_2  Orientation_ankle_3  Orientation_ankle_4
subject_id
0                  0.0                  0.0                  0.0
1
1                  0.0                  0.0                  0.0
1
2                  0.0                  0.0                  0.0
1
3                  0.0                  0.0                  0.0
1
4                  0.0                  0.0                  0.0
1
5                  0.0                  0.0                  0.0
1
6                  0.0                  0.0                  0.0
1
7                  0.0                  0.0                  0.0
1
8                  0.0                  0.0                  0.0
1
9                  0.0                  0.0                  0.0
1

[10 rows x 55 columns]
```

## Data Cleaning

The data_cleaning() takes datafr(dataframe created at the begining of the process) as input and phydata(dataframe after cleaning) is obtained as its output. Here in data cleaning we will be focusing on four steps:

- Dropping the irrelevant columns: Going further, I won't require any of the orientation columns for analysis so I will remove those columns.
- Removing the rows with activityID=0: For further analysis I won't be considering the activities with activityID = 0 as the subjects are not doing any task.
- Removal of null values: Here to remove all the null values, I will use interpolate function. Since in the dataset records the reading is taken every millisecond and the various IMU reading won't change drastically so I will assume the null value will be similar to the above row.For all columns, except heart rate, null values are removed using the interpolate() method. Heartrate has been replaced with the mean heart rate of each activity group in place of null values. Even after applying interpolation() to heartrate, there are NaN values that can either be filled with an assumed value, but instead I have replaced them with 100.
- Converting values into numeric value: Since our data is all about different readings which are recorded in number type I will be converting all the values which are in non numeric format into numeric type

```
def fill_null_heartrate(datafr):
    #funtion : fill_null_heartrate : replace the null values in
heartrate column with 100
    #parameters : datafr : dataframe

    act_name=list(set(datafr['activityID'].values))
    datedd=datafr
    for act in act_name:

        datedd.loc[datedd['activityID']== act,
['heartrate']]=datedd.loc[datedd['activityID']== act,
['heartrate']].fillna(100)
    return datedd

def data_cleaning(dataCollection):

        # removal of orientation columns as they are not needed
        dataCollection = dataCollection.drop(['Orientation_hand_1',
'Orientation_hand_2', 'Orientation_hand_3', 'Orientation_hand_4',
                                             'Orientation_chest_1',
'Orientation_chest_2', 'Orientation_chest_3', 'Orientation_chest_4',
                                             'Orientation_ankle_1',
'Orientation_ankle_2', 'Orientation_ankle_3', 'Orientation_ankle_4'],
                                            axis = 1)
```

```
        #removal of any row of activity 0 as it is transient activity
which it is not used
        dataCollection =
dataCollection.drop(dataCollection[dataCollection.activityID ==
0].index)


        #removal of any remaining NaN value cells by constructing new
data points in known set of data points
        dataCollection = dataCollection.interpolate()

        #call fill_null_heartrate()
        dataCollection=fill_null_heartrate(dataCollection)

        #removal of non numeric data in cells
        dataCollection = dataCollection.apply(pd.to_numeric, errors =
'coerce')

        return dataCollection

phydata=data_cleaning(datafr)
phydata.reset_index(drop = True, inplace = True)
phydata
```

```
         timestamp  activityID  heartrate  Temperature_hand  \
2927         37.66           1      100.0            30.375
2928         37.67           1      100.0            30.375
2929         37.68           1      100.0            30.375
2930         37.69           1      100.0            30.375
2931         37.70           1      100.0            30.375
...            ...         ...        ...               ...
2872006      95.06          24      162.0            25.125
2872007      95.07          24      162.0            25.125
2872008      95.08          24      162.0            25.125
2872009      95.09          24      162.0            25.125
2872010      95.10          24      162.0            25.125

         3D_hand_Accl_16_1  3D_hand_Accl_16_2  3D_hand_Accl_16_3  \
2927               2.21530            8.27915            5.58753
2928               2.29196            7.67288            5.74467
2929               2.29090            7.14240            5.82342
2930               2.21800            7.14365            5.89930
2931               2.30106            7.25857            6.09259
...                    ...                ...                ...
2872006            4.99466            6.01881            5.59830
2872007            5.02764            5.90369            5.48372
2872008            5.06409            5.71370            5.48491
2872009            5.13914            5.63724            5.48629
2872010            5.00812            5.40645            5.02326
```

```
         3D_hand_Accl_6_1  3D_hand_Accl_6_2  3D_hand_Accl_6_3  ...  \
2927              2.24689           8.55387           5.77143  ...   
2928              2.27373           8.14592           5.78739  ...   
2929              2.26966           7.66268           5.78846  ...   
2930              2.22177           7.25535           5.88000  ...   
2931              2.20720           7.24042           5.95555  ...   
...                   ...               ...               ...  ...   
2872006           4.90787           6.05780           5.68357  ...   
2872007           4.89090           5.95209           5.56301  ...   
2872008           4.97981           5.87584           5.45738  ...   
2872009           4.97690           5.69448           5.29167  ...   
2872010           4.97362           5.45272           5.14120  ...   

         3D_ankle_Accl_6_1  3D_ankle_Accl_6_2  3D_ankle_Accl_6_3  \
2927               9.63162           -1.76757           0.265761   
2928               9.58649           -1.75247           0.250816   
2929               9.60196           -1.73721           0.356632   
2930               9.58674           -1.78264           0.311453   
2931               9.64677           -1.75240           0.295902   
...                    ...                ...                ...   
2872006            9.41274           -2.26922          -1.759580   
2872007            9.33733           -2.23908          -1.834950   
2872008            9.32243           -2.23905          -1.804610   
2872009            9.38220           -2.26938          -1.880500   
2872010            9.41250           -2.23905          -1.820220   

         3D_ankleGyro_1  3D_ankleGyro_2  3D_ankleGyro_3  
3D_anklemagneto_1  \
2927           0.002908       -0.027714        0.001752           -
61.1081   
2928           0.020882        0.000945        0.006007           -
60.8916   
2929          -0.035392       -0.052422       -0.004882           -
60.3407   
2930          -0.032514       -0.018844        0.026950           -
60.7646   
2931           0.001351       -0.048878       -0.006328           -
60.2040   
...                 ...             ...             ...                
...   
2872006        0.021288       -0.012885        0.005878           -
45.7855   
2872007        0.010715        0.003629       -0.004235           -
46.0331   
2872008       -0.016939       -0.035176       -0.002309           -
45.5140   
2872009       -0.028069       -0.036457       -0.007076           -
45.9093   
2872010       -0.013310       -0.030195        0.018229           -
46.1702   
```

```
         3D_anklemagneto_2  3D_anklemagneto_3  subject_id
2927            -36.863600         -58.369600           1
2928            -36.319700         -58.365600           1
2929            -35.784200         -58.611900           1
2930            -37.102800         -57.879900           1
2931            -37.122500         -57.884700           1
...                    ...                ...         ...
2872006          -0.831734          -0.170139           9
2872007          -0.817288           0.538134           9
2872008          -1.229410           0.540438           9
2872009          -0.565555           0.680109           9
2872010          -0.812965          -0.313346           9

[1942872 rows x 43 columns]
```

```
phydata.head()
```

```
   timestamp  activityID  heartrate  Temperature_hand
3D_hand_Accl_16_1  \
0      37.66           1      100.0            30.375
2.21530
1      37.67           1      100.0            30.375
2.29196
2      37.68           1      100.0            30.375
2.29090
3      37.69           1      100.0            30.375
2.21800
4      37.70           1      100.0            30.375
2.30106

   3D_hand_Accl_16_2  3D_hand_Accl_16_3  3D_hand_Accl_6_1
3D_hand_Accl_6_2  \
0            8.27915            5.58753           2.24689
8.55387
1            7.67288            5.74467           2.27373
8.14592
2            7.14240            5.82342           2.26966
7.66268
3            7.14365            5.89930           2.22177
7.25535
4            7.25857            6.09259           2.20720
7.24042

   3D_hand_Accl_6_3  ...  3D_ankle_Accl_6_1  3D_ankle_Accl_6_2  \
0           5.77143  ...            9.63162           -1.76757
1           5.78739  ...            9.58649           -1.75247
2           5.78846  ...            9.60196           -1.73721
3           5.88000  ...            9.58674           -1.78264
4           5.95555  ...            9.64677           -1.75240
```

```
   3D_ankle_Accl_6_3  3D_ankleGyro_1  3D_ankleGyro_2
3D_ankleGyro_3  \
0           0.265761        0.002908       -0.027714        0.001752

1           0.250816        0.020882        0.000945        0.006007

2           0.356632       -0.035392       -0.052422       -0.004882

3           0.311453       -0.032514       -0.018844        0.026950

4           0.295902        0.001351       -0.048878       -0.006328


   3D_anklemagneto_1  3D_anklemagneto_2  3D_anklemagneto_3  subject_id

0           -61.1081           -36.8636           -58.3696           1

1           -60.8916           -36.3197           -58.3656           1

2           -60.3407           -35.7842           -58.6119           1

3           -60.7646           -37.1028           -57.8799           1

4           -60.2040           -37.1225           -57.8847           1


[5 rows x 43 columns]
```

```
phydata.isnull().sum()
```

```
timestamp              0
activityID             0
heartrate              0
Temperature_hand       0
3D_hand_Accl_16_1      0
3D_hand_Accl_16_2      0
3D_hand_Accl_16_3      0
3D_hand_Accl_6_1       0
3D_hand_Accl_6_2       0
3D_hand_Accl_6_3       0
3D_handGyro_1          0
3D_handGyro_2          0
3D_handGyro_3          0
3D_handmagneto_1       0
3D_handmagneto_2       0
3D_handmagneto_3       0
Temperature_chest      0
3D_chest_Accl_16_1     0
```

```
3D_chest_Accl_16_2    0
3D_chest_Accl_16_3    0
3D_chest_Accl_6_1     0
3D_chest_Accl_6_2     0
3D_chest_Accl_6_3     0
3D_chestGyro_1        0
3D_chestGyro_2        0
3D_chestGyro_3        0
3D_chestmagneto_1     0
3D_chestmagneto_2     0
3D_chestmagneto_3     0
Temperature_ankle     0
3D_ankle_Accl_16_1    0
3D_ankle_Accl_16_2    0
3D_ankle_Accl_16_3    0
3D_ankle_Accl_6_1     0
3D_ankle_Accl_6_2     0
3D_ankle_Accl_6_3     0
3D_ankleGyro_1        0
3D_ankleGyro_2        0
3D_ankleGyro_3        0
3D_anklemagneto_1     0
3D_anklemagneto_2     0
3D_anklemagneto_3     0
subject_id            0
dtype: int64
```

The data cleaning phase is now complete. The final dataframe "phydata" contains all the information and is ready for the next phase "Exploratory data analysis".

## Exploratory Data Analysis

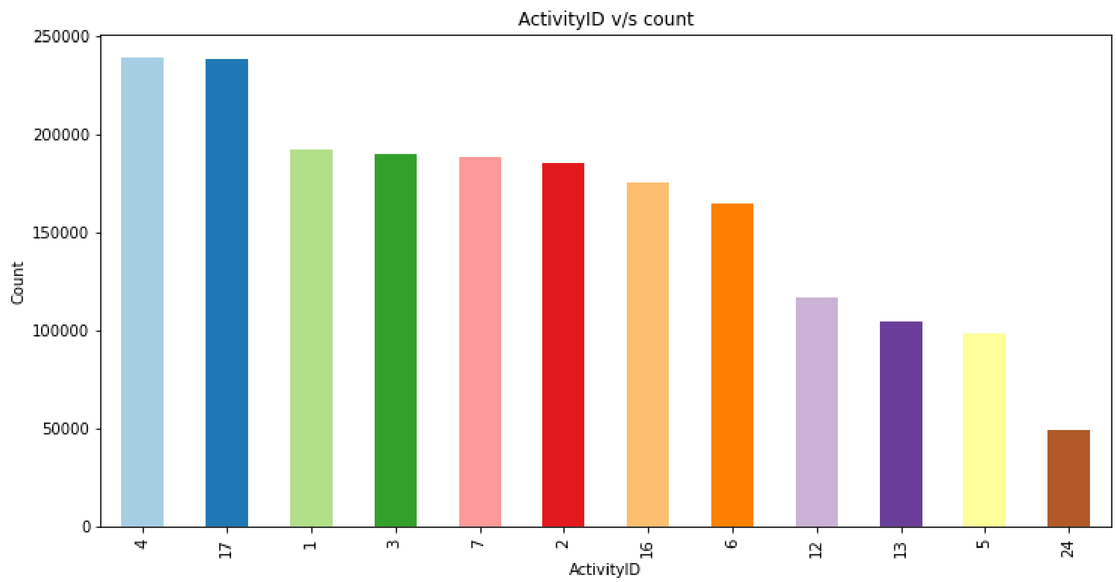
During this phase, all EDA analyses are conducted. The analysis is conducted using 'phydata' as input and 'graphs based on the analysis' are generated as output.

The process includes:-

- Generation of test and train data
- Activity time analysis by subjectID
- Analysis on activity by heartrate
- Analysis on activity by calorie burnt
- Analysis on activity by heart, chest and ankle temperature
- Correlation analysis

It is important to check if a dataframe is balanced before splitting it into a test and train set because unbalanced data can affect the performance of a machine learning model. If the data is unbalanced, meaning that one class is significantly more prevalent than the other class, the model may be biased towards the more prevalent class. This can lead to poor performance on the less prevalent class.

```
size = range(len(phydata))
phydata['activityID'].value_counts().plot(kind = "bar",figsize =
(12,6),color=plt.cm.Paired(size))
plt.xlabel("ActivityID")
plt.ylabel("Count")
plt.title('ActivityID v/s count')
plt.show()
```




We can see from the bar graph that the dataframe is balanced, so we can split it into test and train sets.

### Generation of test and train data

The test and train data are generated by splitting the data frame in half, i.e. 0.5.

```
def splitting_train_test(dataframe,n=0.5):
    train_df = dataframe.sample(frac=n, random_state=1)
    test_df = dataframe.drop(train_df.index)
    return train_df,test_df

training_data,testing_data = splitting_train_test(phydata,0.5)

training_data.describe()

           timestamp     activityID      heartrate
Temperature_hand  \
count  971436.000000  971436.000000  971436.000000     971436.000000

mean     1703.994666       8.081953     107.445857         32.751715
```

```
std      1093.247832      6.174908      26.975255        1.793871

min        31.220000      1.000000      57.000000       24.875000

25%       744.560000      3.000000      86.000000       31.687500

50%      1478.680000      6.000000     104.000000       33.125000

75%      2662.552500     13.000000     124.000000       34.062500

max      4245.680000     24.000000     202.000000       35.500000


       3D_hand_Accl_16_1  3D_hand_Accl_16_2  3D_hand_Accl_16_3  \
count      971436.000000      971436.000000      971436.000000
mean           -4.956991           3.579835           3.612234
std             6.244104           6.881571           3.962008
min          -145.367000        -104.301000        -101.452000
25%            -8.970760           1.060202           1.171568
50%            -5.449225           3.525055           3.442250
75%            -0.964139           6.451445           6.533720
max            62.859600         155.699000         157.760000

       3D_hand_Accl_6_1  3D_hand_Accl_6_2  3D_hand_Accl_6_3  ...  \
count     971436.000000     971436.000000     971436.000000  ...
mean          -4.890270          3.570034          3.796905  ...
std            6.249035          6.593962          3.946777  ...
min          -61.214700        -61.841700        -61.934700  ...
25%           -8.866962          1.060518          1.373687  ...
50%           -5.378790          3.566135          3.674970  ...
75%           -0.909503          6.458100          6.785285  ...
max           45.548400         62.259800         61.728000  ...

       3D_ankle_Accl_6_1  3D_ankle_Accl_6_2  3D_ankle_Accl_6_3  \
count      971436.000000      971436.000000      971436.000000
mean            9.370013          -0.046497          -2.176481
std             6.068911           7.187835           3.477410
min           -61.142000         -61.903500         -62.203800
25%             8.394965          -2.073703          -3.398802
50%             9.549240          -0.223893          -1.992215
75%            10.278000           1.920240          -0.595102
max            61.969300          62.049000          55.553400

       3D_ankleGyro_1  3D_ankleGyro_2  3D_ankleGyro_3
3D_anklemagneto_1  \
count   971436.000000   971436.000000   971436.000000
971436.000000
mean         0.011323       -0.035935        0.007185          -
31.582509
```

```
std          1.124865        0.637566        2.009187
18.346495
min        -13.592200       -7.324840      -12.977400        -
172.624000
25%         -0.207035       -0.106357       -0.437332         -
41.694300
50%          0.004692       -0.003908       -0.002289         -
33.998050
75%          0.131925        0.116567        0.091502         -
17.897800
max         16.442700       13.588200       14.482700
91.551600

       3D_anklemagneto_2  3D_anklemagneto_3     subject_id
count      971436.000000      971436.000000  971436.000000
mean            1.404674          17.253204       4.565264
std            21.685612          19.705747       2.332310
min          -137.908000        -102.716000       1.000000
25%           -12.443825           3.813545       2.000000
50%             0.779744          18.771850       5.000000
75%            17.840625          31.241150       7.000000
max            93.699200         139.787000       9.000000

[8 rows x 43 columns]

training_data.sort_index()

         timestamp  activityID  heartrate  Temperature_hand  \
0            37.66           1      100.0            30.375
2            37.68           1      100.0            30.375
3            37.69           1      100.0            30.375
5            37.71           1      100.0            30.375
6            37.72           1      100.0            30.375
...            ...         ...        ...               ...
1942859      94.98          24      162.0            25.125
1942861      95.00          24      162.0            25.125
1942862      95.01          24      162.0            25.125
1942863      95.02          24      162.0            25.125
1942865      95.04          24      162.0            25.125

         3D_hand_Accl_16_1  3D_hand_Accl_16_2  3D_hand_Accl_16_3  \
0                  2.21530            8.27915            5.58753
2                  2.29090            7.14240            5.82342
3                  2.21800            7.14365            5.89930
5                  2.07165            7.25965            6.01218
6                  2.41148            7.59780            5.93915
...                    ...                ...                ...
1942859            4.81452            6.51482            5.74788
1942861            5.07290            6.39761            5.59819
1942862            4.95472            6.28366            5.48134
```

```
1942863          4.80517          6.32311          5.51746
1942865          4.95740          6.28434          5.55836

        3D_hand_Accl_6_1  3D_hand_Accl_6_2  3D_hand_Accl_6_3  ...  \
0                2.24689           8.55387           5.77143  ...
2                2.26966           7.66268           5.78846  ...
3                2.22177           7.25535           5.88000  ...
5                2.19238           7.21038           6.01604  ...
6                2.23988           7.46679           6.03053  ...
...                  ...               ...               ...  ...
1942859          4.89736           6.49594           5.78832  ...
1942861          4.94094           6.45017           5.63737  ...
1942862          4.93917           6.35946           5.51677  ...
1942863          4.89281           6.22387           5.51711  ...
1942865          4.81809           6.22448           5.59269  ...

        3D_ankle_Accl_6_1  3D_ankle_Accl_6_2  3D_ankle_Accl_6_3  \
0                 9.63162           -1.76757           0.265761
2                 9.60196           -1.73721           0.356632
3                 9.58674           -1.78264           0.311453
5                 9.60177           -1.75239           0.311276
6                 9.67694           -1.76748           0.326060
...                   ...                ...                ...
1942859           9.44267           -1.99702          -1.806020
1942861           9.44276           -2.13311          -1.775310
1942862           9.39788           -2.13306          -1.729670
1942863           9.48793           -2.20869          -1.745040
1942865           9.36713           -2.42063          -1.879930

        3D_ankleGyro_1  3D_ankleGyro_2  3D_ankleGyro_3
3D_anklemagneto_1  \
0             0.002908       -0.027714        0.001752           -
61.1081
2            -0.035392       -0.052422       -0.004882           -
60.3407
3            -0.032514       -0.018844        0.026950           -
60.7646
5             0.003793       -0.026906        0.004125           -
61.3257
6             0.036814       -0.032277       -0.006866           -
61.5520
...                ...             ...             ...
...
1942859      -0.036682       -0.011895       -0.017897           -
45.9167
1942861       0.027636       -0.024815       -0.022575           -
46.2808
1942862      -0.005801       -0.007817        0.009006           -
45.9034
1942863      -0.028744       -0.061156        0.033653           -
```

```
46.0452
1942865       -0.041091       -0.019494       0.014317           -
45.8890

         3D_anklemagneto_2  3D_anklemagneto_3  subject_id
0               -36.863600         -58.369600           1
2               -35.784200         -58.611900           1
3               -37.102800         -57.879900           1
5               -36.974400         -57.750100           1
6               -36.963200         -57.995700           1
...                    ...                ...         ...
1942859          -0.437698           0.254439           9
1942861          -1.320750           0.254182           9
1942862          -1.211660          -0.028281           9
1942863          -0.690454          -0.313048           9
1942865          -1.596940           0.539545           9

[971436 rows x 43 columns]
```

### Activity time analysis by subjectID

Let us consider the amount of time each subject spent performing different types of physical activity. As a result, the activityID is mapped with the activity's name to create a dataframe named phydatacop.

```
phydatacop=training_data.copy()
phydatacop.activityID=phydatacop.activityID.apply(lambda
x:activityIDdict[x])
phydatacop
```

```
         timestamp        activityID   heartrate  Temperature_hand  \
312921      767.77          standing   90.000000           34.1875
141735     1926.37  ascending_stairs  167.909091           33.6875
1191085    3749.31      rope_jumping  181.000000           33.8125
1206914     255.84             lying   62.000000           33.4375
1710520     491.73           sitting   79.000000           34.3125
...            ...               ...         ...               ...
471794     3648.85           cycling  120.000000           29.7500
46078       498.44           sitting   92.000000           32.5625
495388     3961.26           running  139.000000           28.8750
1506095     783.52           ironing   74.000000           33.3750
699375      192.56             lying   72.000000           32.7500

         3D_hand_Accl_16_1  3D_hand_Accl_16_2  3D_hand_Accl_16_3  \
312921            -8.52981           4.712060           0.358276
141735           -11.23140           2.967660           2.325040
1191085           -1.77987           3.716760          -7.388680
1206914            4.89177          -0.216854           8.273420
1710520           -1.96494          -9.487270           0.889387
...                    ...                ...                ...
```

```
471794           -6.10533         3.427980         7.365140
46078            -7.87425         4.095880         4.141940
495388           -5.33359        36.979800        -3.435980
1506095           2.11020        11.319200        -2.429680
699375            5.04452         0.198974         8.235820

         3D_hand_Accl_6_1  3D_hand_Accl_6_2  3D_hand_Accl_6_3  ...  \
312921          -8.254460          4.955160          0.791698  ...
141735         -10.353600          2.978210          2.293150  ...
1191085         -0.572605          3.958700         -4.197230  ...
1206914          5.134350         -0.344501          8.596710  ...
1710520         -1.802600         -9.468570          1.058310  ...
...                   ...               ...               ...  ...
471794          -6.577840          4.301450          9.142140  ...
46078           -7.704180          4.138990          4.356700  ...
495388          -3.119450         34.862600         -2.873060  ...
1506095          2.211510         12.367400         -2.346000  ...
699375           5.409190          0.227261          8.444170  ...

         3D_ankle_Accl_6_1  3D_ankle_Accl_6_2  3D_ankle_Accl_6_3  \
312921            9.716540          -1.511980          -1.006870
141735           11.137500          -1.301760          -2.513480
1191085          -4.136650          -4.006830           2.162320
1206914          -0.117976          -9.411680          -2.836260
1710520           9.187270           2.903000          -2.153400
...                    ...                ...                ...
471794           10.602400          -2.752050          -1.022720
46078             9.135820           1.192120          -3.570340
495388           11.857500           5.583830           0.381641
1506095           9.890210          -0.561093          -2.660590
699375            2.514220          -9.420820           1.569270

         3D_ankleGyro_1  3D_ankleGyro_2  3D_ankleGyro_3
3D_anklemagneto_1  \
312921         0.079272       -0.003718       -0.076595           -
18.7246
141735        -0.276670        0.669698       -0.143689           -
51.7218
1191085        1.877290       -0.176273       -0.654045           -
44.6465
1206914       -0.008012        0.002114        0.017758           -
17.3221
1710520        0.010209        0.011341        0.028921           -
19.4371
...                 ...             ...             ...
...
471794         0.154275        0.059888        0.106166           -
41.1119
46078          0.063705        0.008307        0.002250           -
85.4454
```

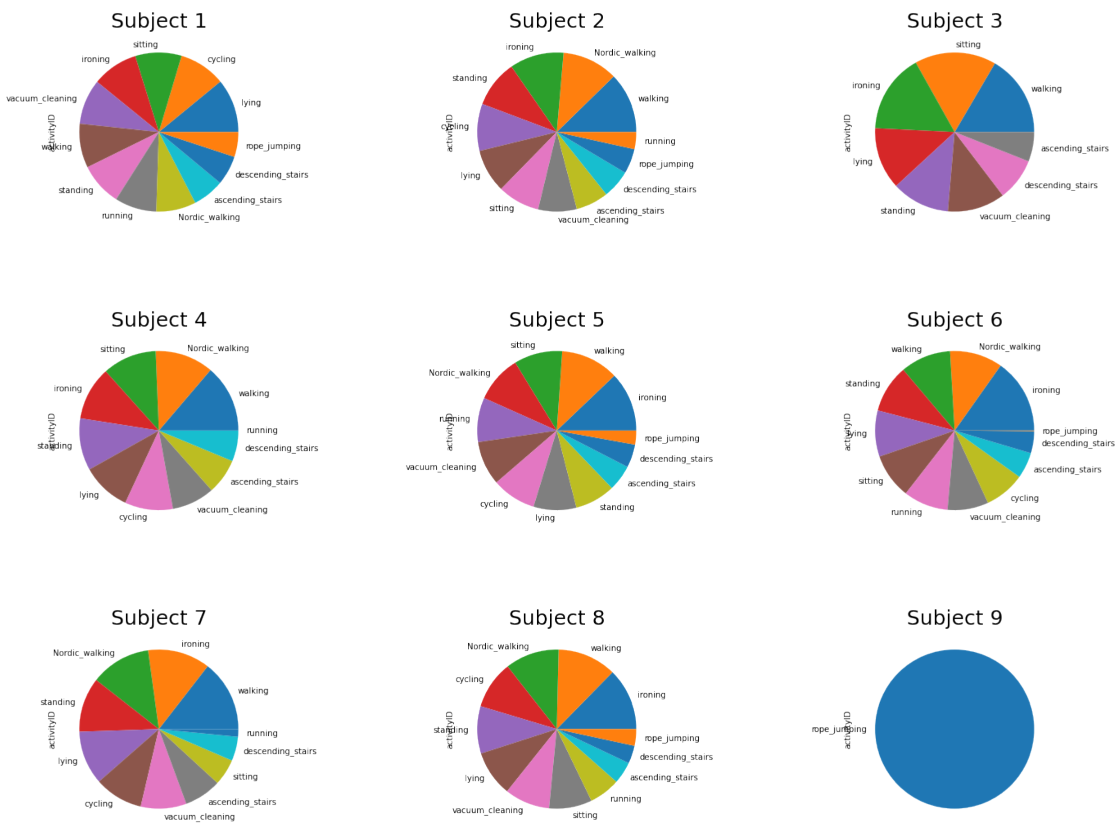
```
495388        -1.355570       1.238730      -3.278750           -
51.4954
1506095        0.426933      -0.741163       0.191537           -
33.2568
699375        -0.070824       0.009968       0.010577           -
21.4016

         3D_anklemagneto_2  3D_anklemagneto_3  subject_id
312921           -16.87960          36.806500           2
141735            33.83850          -6.571620           1
1191085          -12.21680           0.272571           5
1206914           26.44510          -4.782110           6
1710520           15.82690          26.000300           8
...                    ...                ...         ...
471794             5.34881           8.881400           2
46078             38.14700          16.401700           1
495388            -5.78950          36.450200           2
1506095           -1.96371          46.112500           7
699375            15.80880         -13.294100           4

[971436 rows x 43 columns]
```

Using a pie chart, we examine the time subjects spend on each activity (excluding the optional data given).

```
def plot(df, sub, ax):

    df.activityID.value_counts().plot(kind='pie', ax=ax)
    df.activityID.agg(['value_counts'])
    ax.set_title('Subject {}'.format(sub), fontsize=25)

# Add a title to the entire figure
print('Time spend for each activity by subjects')

# Create a figure with 3 rows and 3 columns of subplots, with a larger
size
fig, ax = plt.subplots(3, 3, figsize=(9, 9))

# Iterate through the subject IDs
for i, sub in enumerate([1,2,3, 4,5,6,7,8,9]):
    # Plot the pie chart for the subject and assign it to the
appropriate subplot
    plot(phydatacop[phydatacop['subject_id']==sub], sub, ax[i // 3][i
% 3])



# Adjust the spacing between the subplots
plt.subplots_adjust(left=0, bottom=0.5, right=2, top=2, wspace=0.5,
hspace=0.5)
```

```
# Show the plot
plt.show()
```

Time spend for each activity by subjects




### Analysis on activity by heartrate

Let us consider now consider the average heartrate measured while performing various physical activities.

```
df_grouped=training_data.groupby(['activityID']).mean()
df_grouped=df_grouped.reset_index()
df_grouped
```

```
    activityID    timestamp   heartrate  Temperature_hand
3D_hand_Accl_16_1  \
0            1   205.810018   75.545557         32.728505
3.679602
1            2   506.308536   80.047179         33.258141          -
1.389341
2            3   733.377930   88.536730         33.637740          -
7.075932
3            4  2429.595921  112.779310         32.303069         -
10.107593
4            5  3445.280586  156.609147         30.819405          -
```

```
6.504239
5            6  3128.694951  124.830549         31.009282          -
5.154956
6            7  2903.735748  123.775604         31.528332          -
4.737611
7           12  1806.752318  129.518261         33.528458          -
8.733582
8           13  1905.608580  129.094747         33.323658          -
6.282657
9           16  1359.725161  104.182793         34.176997          -
7.162320
10          17  1026.179980   90.045718         34.022595          -
3.375883
11          24  3349.758610  161.966847         29.713111          -
4.206803

    3D_hand_Accl_16_2  3D_hand_Accl_16_3  3D_hand_Accl_6_1
3D_hand_Accl_6_2  \
0            2.061675           6.367305          3.791752
2.032754
1            4.295544           5.173842         -1.262264
4.294076
2            3.223117           2.675270         -6.939606
3.266560
3            2.515623           1.922580        -10.100182
2.545913
4            6.728369           0.287698         -6.624070
6.352816
5            2.507518           7.122948         -5.158149
2.506534
6            5.079735           2.543156         -4.736760
5.078315
7            3.658778           1.603061         -8.643621
3.695112
8            2.910228           3.656226         -6.184478
2.924561
9            3.575758           1.913401         -7.031500
3.595148
10           3.752365           5.447087         -3.246341
3.745548
11           5.390808          -0.530344         -4.326484
5.410021

    3D_hand_Accl_6_3  ...  3D_ankle_Accl_6_1  3D_ankle_Accl_6_2  \
0           6.588179  ...           0.543936          -6.226228
1           5.383078  ...           8.809982          -0.216851
2           2.893323  ...           9.380298          -0.741048
3           2.092860  ...          11.959444           0.632620
4           0.388420  ...          13.193339           2.880917
5           7.262646  ...           9.130031           2.129800
```

```
6           2.692999  ...         12.262297          0.872126
7           1.801738  ...          9.788651          1.604495
8           3.853605  ...         10.742766          1.154140
9           2.132941  ...          9.563327          0.435375
10          5.665965  ...          9.601066         -0.401777
11         -0.539632  ...          9.907947          1.084461

    3D_ankle_Accl_6_3  3D_ankleGyro_1  3D_ankleGyro_2  3D_ankleGyro_3
\
0           -3.316962        0.010893       -0.005854        0.006003

1           -2.089557        0.006796       -0.005329        0.005010

2           -1.643213        0.004367       -0.004551        0.004309

3           -2.693545       -0.005349       -0.113771       -0.000048

4           -3.189012        0.002644       -0.100271       -0.037299

5           -1.068567        0.085572        0.038773        0.003845

6           -2.906883       -0.004517       -0.140149        0.006245

7           -2.708451        0.385221        0.133281       -0.006582

8           -2.114203       -0.405388       -0.242240        0.111473

9           -1.281936       -0.002207        0.005179        0.004223

10          -1.457873        0.011071       -0.002973        0.002770

11          -2.047257        0.009809       -0.009883        0.012182


    3D_anklemagneto_1  3D_anklemagneto_2  3D_anklemagneto_3
subject_id
0          -17.937375          20.577229           0.134306
4.485731
1          -22.525800           2.503881          21.125203
4.306876
2          -22.656027          -0.594149          24.427203
4.593166
3          -36.985424          -0.592640          15.840951
4.623625
4          -36.532773          -8.301071          13.229515
4.663884
5          -38.848188          -6.929358          12.873313
4.701040
6          -37.386417          -0.656277          14.345998
```

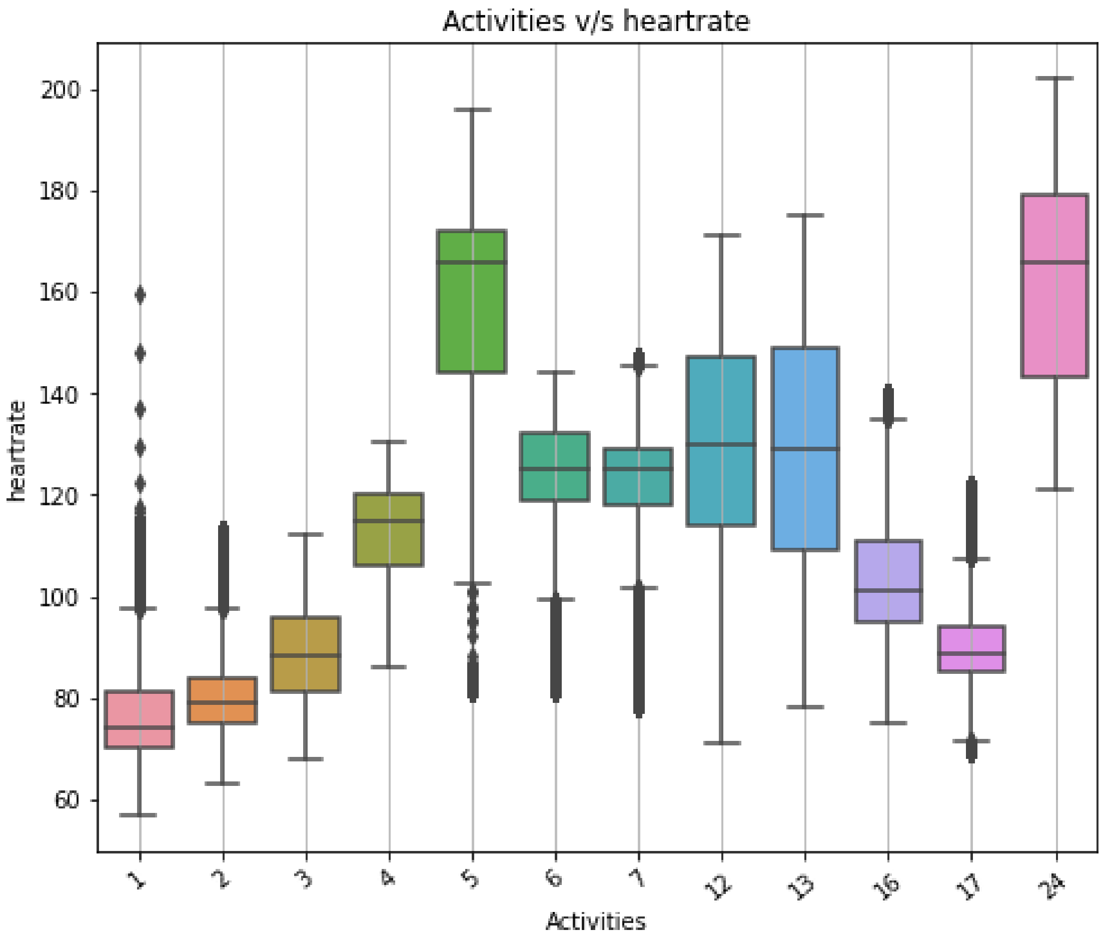
```
4.851653
7          -35.736146          -4.829318          13.768898
4.402396
8          -36.826082          -4.451120          20.214430
4.166409
9          -24.416449           4.187497          11.367237
4.550262
10         -38.835212           5.579286          34.094910
4.726989
11         -40.243773          -8.196516          23.698923
4.221707

[12 rows x 43 columns]
```

```
df_grouped['activity_name']=1
for i in range(len(df_grouped['activityID'])):
    df_grouped['activity_name']
[i]=activityIDdict[df_grouped['activityID'][i]]

df_grouped[['activityID','activity_name','heartrate']]
```

```
    activityID      activity_name   heartrate
0            1              lying   75.545557
1            2            sitting   80.047179
2            3           standing   88.536730
3            4            walking  112.779310
4            5            running  156.609147
5            6            cycling  124.830549
6            7     Nordic_walking  123.775604
7           12   ascending_stairs  129.518261
8           13  descending_stairs  129.094747
9           16    vacuum_cleaning  104.182793
10          17            ironing   90.045718
11          24       rope_jumping  161.966847
```

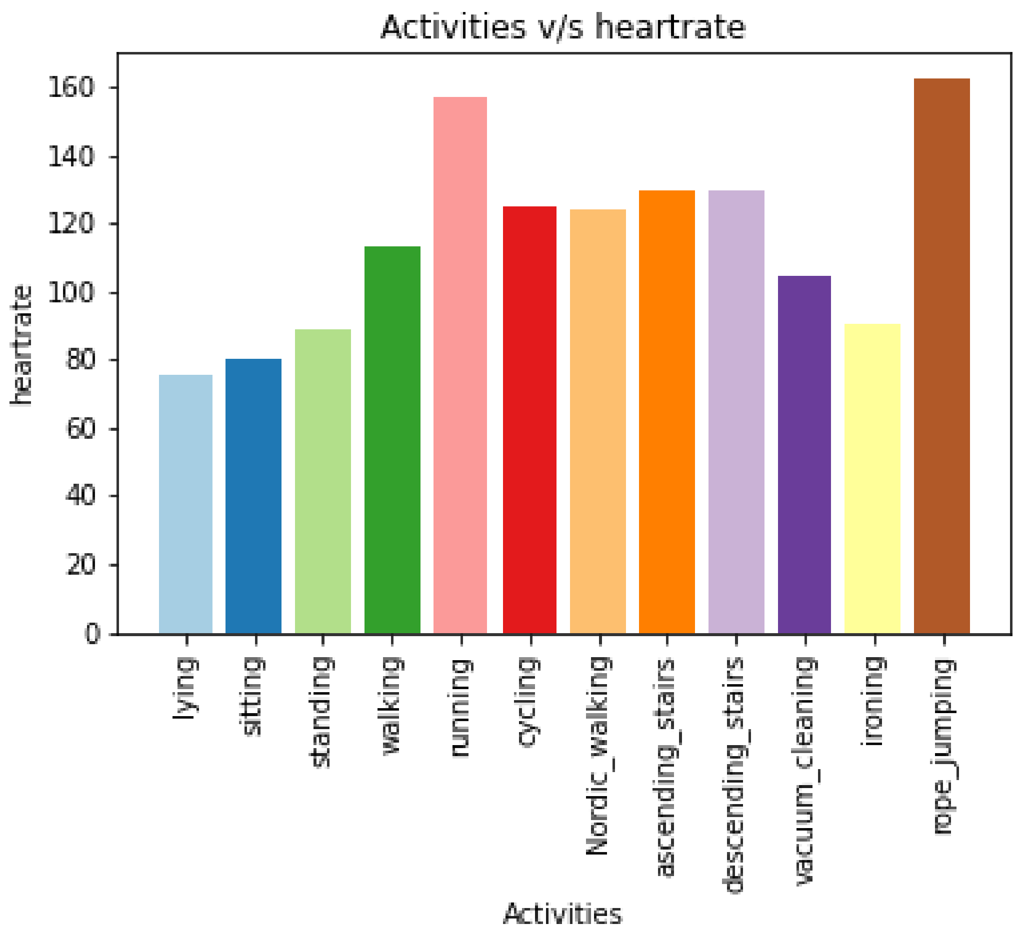
### Boxplot for Activities v/s heartrate

```
import seaborn as sns
plt.figure(figsize=(7,5))
plt.subplots_adjust(2,1,5,2)
plt.subplot(131)
dat1=training_data[['activityID','heartrate']]
#dat1.activityID=dat1.activityID.astype("category")
plt.xticks(rotation=40)
sns.boxplot(x='activityID',y='heartrate',data=dat1)
plt.grid(axis='x')
plt.ylabel('heartrate')
plt.xlabel('Activities')
plt.title('Activities v/s heartrate')
plt.show()
```




**Bar graph for Activities v/s heartrate**

```
size = range(len(df_grouped))
plt.bar(df_grouped['activity_name'],df_grouped['heartrate'],color=plt.
cm.Paired(size))
plt.xticks(rotation=90)
plt.xlabel('Activities')
plt.ylabel('heartrate')
plt.title('Activities v/s heartrate')
plt.show()
```




Based on our analysis, we can conclude that rope jumping produces the highest heart rate, followed by running. Lying results in the lowest heart rate.

### Analysis on activity by calorie burnt

As part of this analysis, we will consider how many calories the subjects burnt during various activities. Calorie_burnt is calculated in calorie_calc() based on the MET value and the weight of each subject. Next, a new dataframe activity_subject_group is created from training_data dataframe by grouping activityID and subjectID, then applying the mean, max, and min functions to the timestamp column for each group, and the value of calories burnt is added to that dataframe. Another dataframe calorie_on_acti is created by grouping the activityID and subjectID of activity_subject_group and taking their mean. The activityID is mapped to an activityName so that a clear understanding can be gained.

```
def calorie_calc(i):

    T=60
    MET=MET_values[activity_subject_group['activityID'][i]]
    W=subject_weights[activity_subject_group['subject_id'][i]]
    calories= T * MET * 3.5 * W / (200 * 60)
```

```
    return calories

activity_subject_group=training_data.groupby(['activityID','subject_id
'])['timestamp'].agg([np.mean,max,min])
activity_subject_group=activity_subject_group.reset_index()
activity_subject_group['calorie_burnt']=0
for i in range(len(activity_subject_group['activityID'])):
    activity_subject_group['calorie_burnt'][i]=calorie_calc(i)

calorie_on_acti=activity_subject_group.groupby(['activityID','subject_
id']).mean()
calorie_on_acti=calorie_on_acti.reset_index()
calorie_on_acti.activityID=calorie_on_acti.activityID.apply(lambda
x:activityIDdict[x])
calorie_on_acti
```

```
      activityID  subject_id         mean      max      min
calorie_burnt
0          lying           1   174.045415   309.52    37.66
1.4525
1          lying           2   171.966434   289.49    55.20
1.3650
2          lying           3   276.886762   386.54   166.14
1.6100
3          lying           4   190.067999   305.69    75.26
1.6625
4          lying           5   223.699684   341.45   104.53
1.2775
..           ...         ...          ...      ...      ...
...
86  rope_jumping           2  4178.977066  4245.68  4113.08
12.2850
87  rope_jumping           5  3714.966443  3753.50  3676.20
11.4975
88  rope_jumping           6  3622.808686  3624.05  3621.50
10.8675
89  rope_jumping           8  3844.586316  3888.41  3800.36
13.7025
90  rope_jumping           9    63.153766    95.04    31.22
10.2375

[91 rows x 6 columns]
```

```
calor_df_for_graph=calorie_on_acti.groupby(['activityID']).mean()
calor_df_for_graph.reset_index(drop=False, inplace=True)
calor_df_for_graph
```

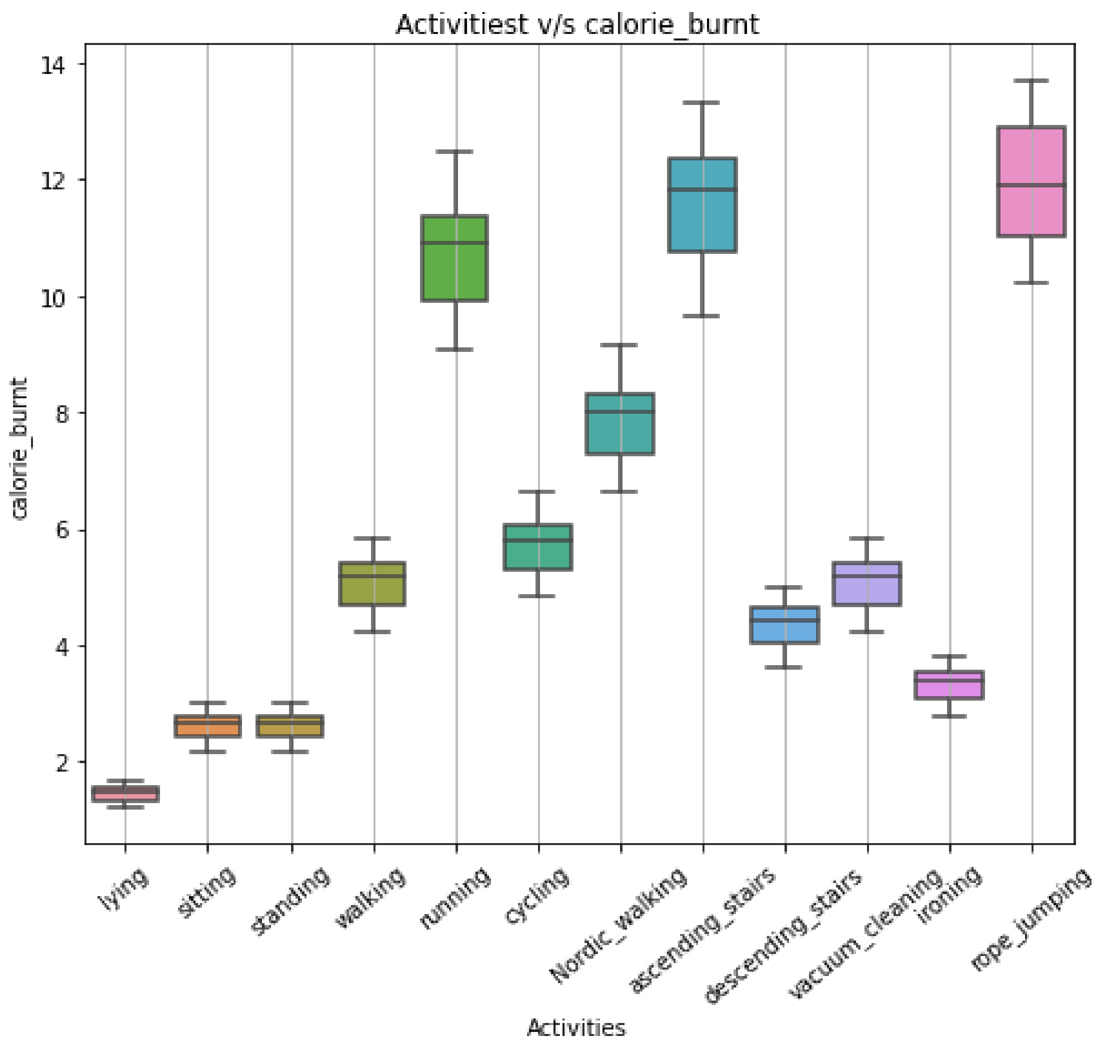
```
           activityID  subject_id         mean          max
min  \
0      Nordic_walking    4.714286  2885.966026  3020.291429
```

```
2751.590000
1    ascending_stairs    4.500000  1807.821634  1999.022500
1615.946250
2             cycling    4.714286  3124.079746  3241.817143
3006.704286
3   descending_stairs    4.500000  1901.256871  2058.310000
1753.810000
4             ironing    4.500000  1023.305778  1172.390000
874.068750
5               lying    4.500000   206.958464   327.148750
86.527500
6        rope_jumping    5.166667  3164.427640  3205.508333
3123.270000
7             running    4.714286  3432.242946  3502.458571
3362.197143
8             sitting    4.500000   499.172845   614.961250
383.506250
9            standing    4.500000   736.287875   854.913750
617.530000
10    vacuum_cleaning    4.500000  1358.443971  1468.221250
1249.055000
11            walking    4.500000  2426.017357  2575.397500
2276.978750

    calorie_burnt
0        7.851250
1       11.602500
2        5.710000
3        4.350937
4        3.335719
5        1.450312
6       11.943750
7       10.706250
8        2.610562
9        2.610562
10       5.076094
11       5.076094
```

**Box plot for Activitiest v/s calorie_burnt**

```
import seaborn as sns
plt.figure(figsize=(7,5))
plt.subplots_adjust(2,1,5,2)
plt.subplot(131)
dat1=calorie_on_acti[['activityID','calorie_burnt']]
#dat1.activityID=dat1.activityID.astype("category")
plt.xticks(rotation=40)
sns.boxplot(x='activityID',y='calorie_burnt',data=dat1)
plt.grid(axis='x')
plt.xlabel('Activities')
plt.ylabel('calorie_burnt')
```

```python
#   plt.title('Activities and Temperature of chest')
plt.title('Activitiest v/s calorie_burnt')
plt.show()
```



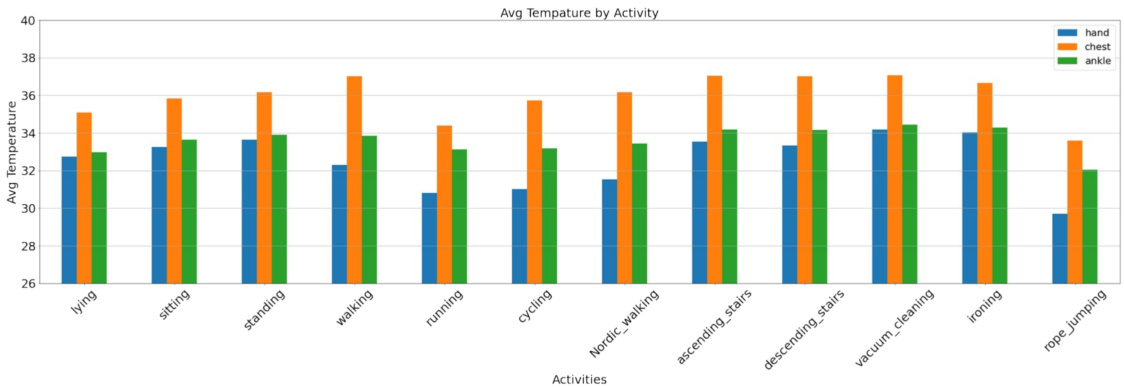

Based on our analysis, we can conclude that calorie_burnt is highest for rope jumping followed by ascending_stairs and running. Lying has the lowest value for calorie_burnt.

### Analysis on activity by heart, chest and ankle temperature

Now let's take a look at the temperature analysis of the hand, chest, and ankle.

```python
mean_tempreture = pd.DataFrame()
mean_tempreture['hand'] = df_grouped['Temperature_hand']
mean_tempreture['chest'] = df_grouped['Temperature_chest']
mean_tempreture['ankle'] = df_grouped['Temperature_ankle']

ax =mean_tempreture.plot(kind='bar', figsize=(40,10), title='Avg
Tempatures by Activity',fontsize=25)
```

```
a = ax.set_xticklabels(df_grouped['activity_name'],rotation=45)
b = ax.legend(fontsize = 20)
c = ax.set_xticks(np.arange(len(samepls_tempreture)))
plt.title('Avg Tempature by Activity',fontsize = 25)
plt.ylim(26, 40)
plt.xlabel('Activities',fontsize=25)
plt.ylabel('Avg Temperature', fontsize=25)
plt.grid(axis='y')
```




According to this graph, we can conclude that the chest temperature is the highest compared to ankle and hand temperatures. The temperatures of the chest, hand, and ankle are higher when ascending_stairs, descending_stairs, Ironing and vacuum_cleaning. rope_jumping has the lowest values.

## Correlation Analysis

Correlation analysis is a statistical technique that is used to evaluate the strength and direction of the relationship between two variables. It measures the degree to which a change in one variable is associated with a change in another variable.

We are mapping the activity ID and activity name here.

```
df_grouped['activity_name']=1
for i in range(len(df_grouped['activityID'])):
    df_grouped['activity_name']
[i]=activityIDdict[df_grouped['activityID'][i]]
df_grouped
```

```
    activityID    timestamp   heartrate  Temperature_hand  
3D_hand_Accl_16_1  \
0            1   205.810018   75.545557         32.728505           
3.679602
1            2   506.308536   80.047179         33.258141          -
1.389341
2            3   733.377930   88.536730         33.637740          -
7.075932
3            4  2429.595921  112.779310         32.303069         -
10.107593
4            5  3445.280586  156.609147         30.819405          -
```

```
6.504239
5            6  3128.694951  124.830549         31.009282         -
5.154956
6            7  2903.735748  123.775604         31.528332         -
4.737611
7           12  1806.752318  129.518261         33.528458         -
8.733582
8           13  1905.608580  129.094747         33.323658         -
6.282657
9           16  1359.725161  104.182793         34.176997         -
7.162320
10          17  1026.179980   90.045718         34.022595         -
3.375883
11          24  3349.758610  161.966847         29.713111         -
4.206803

    3D_hand_Accl_16_2  3D_hand_Accl_16_3  3D_hand_Accl_6_1
3D_hand_Accl_6_2  \
0            2.061675           6.367305          3.791752
2.032754
1            4.295544           5.173842         -1.262264
4.294076
2            3.223117           2.675270         -6.939606
3.266560
3            2.515623           1.922580        -10.100182
2.545913
4            6.728369           0.287698         -6.624070
6.352816
5            2.507518           7.122948         -5.158149
2.506534
6            5.079735           2.543156         -4.736760
5.078315
7            3.658778           1.603061         -8.643621
3.695112
8            2.910228           3.656226         -6.184478
2.924561
9            3.575758           1.913401         -7.031500
3.595148
10           3.752365           5.447087         -3.246341
3.745548
11           5.390808          -0.530344         -4.326484
5.410021

    3D_hand_Accl_6_3  ...  3D_ankle_Accl_6_2  3D_ankle_Accl_6_3  \
0           6.588179  ...          -6.226228          -3.316962
1           5.383078  ...          -0.216851          -2.089557
2           2.893323  ...          -0.741048          -1.643213
3           2.092860  ...           0.632620          -2.693545
4           0.388420  ...           2.880917          -3.189012
5           7.262646  ...           2.129800          -1.068567
```

```
6           2.692999  ...           0.872126          -2.906883
7           1.801738  ...           1.604495          -2.708451
8           3.853605  ...           1.154140          -2.114203
9           2.132941  ...           0.435375          -1.281936
10          5.665965  ...          -0.401777          -1.457873
11         -0.539632  ...           1.084461          -2.047257

    3D_ankleGyro_1  3D_ankleGyro_2  3D_ankleGyro_3  3D_anklemagneto_1
\
0         0.010893       -0.005854        0.006003         -17.937375

1         0.006796       -0.005329        0.005010         -22.525800

2         0.004367       -0.004551        0.004309         -22.656027

3        -0.005349       -0.113771       -0.000048         -36.985424

4         0.002644       -0.100271       -0.037299         -36.532773

5         0.085572        0.038773        0.003845         -38.848188

6        -0.004517       -0.140149        0.006245         -37.386417

7         0.385221        0.133281       -0.006582         -35.736146

8        -0.405388       -0.242240        0.111473         -36.826082

9        -0.002207        0.005179        0.004223         -24.416449

10        0.011071       -0.002973        0.002770         -38.835212

11        0.009809       -0.009883        0.012182         -40.243773


    3D_anklemagneto_2  3D_anklemagneto_3  subject_id
activity_name
0           20.577229           0.134306    4.485731
lying
1            2.503881          21.125203    4.306876
sitting
2           -0.594149          24.427203    4.593166
standing
3           -0.592640          15.840951    4.623625
walking
4           -8.301071          13.229515    4.663884
running
5           -6.929358          12.873313    4.701040
cycling
6           -0.656277          14.345998    4.851653
```

```
Nordic_walking
7           -4.829318          13.768898    4.402396
ascending_stairs
8           -4.451120          20.214430    4.166409
descending_stairs
9            4.187497          11.367237    4.550262
vacuum_cleaning
10           5.579286          34.094910    4.726989
ironing
11          -8.196516          23.698923    4.221707
rope_jumping

[12 rows x 44 columns]
```

In order to reduce the columns we have axis_reducer(), in which we take the sum of the square roots for each of the three values provided. In this way, the heatmap can be easily interpreted.

```
def axis_reducer(df,a,b,c,d):
    ref=df.copy()
    ref[d]=1
    for i in range(len(ref[a])):
#         x=ref[a][i]
#         y=ref[b][i]
#         z=ref[c][i]
#           print(ref[b][i])

        ref[d][i]=(ref[a][i]**2 + ref[b][i]**2 + ref[c][i]**2)**0.5

#         ref[d][i]=dist
    ref=ref.drop([a,b,c], axis=1)



    return ref
```

```
df_correlation=training_data.copy()
df_correlation.reset_index(drop=True, inplace=True)
df_correlation
```

```
        timestamp  activityID   heartrate  Temperature_hand  \
0          767.77           3   90.000000           34.1875
1         1926.37          12  167.909091           33.6875
2         3749.31          24  181.000000           33.8125
3          255.84           1   62.000000           33.4375
4          491.73           2   79.000000           34.3125
...           ...         ...         ...               ...
971431    3648.85           6  120.000000           29.7500
971432     498.44           2   92.000000           32.5625
971433    3961.26           5  139.000000           28.8750
```

```
971434     783.52          17   74.000000          33.3750
971435     192.56           1   72.000000          32.7500

        3D_hand_Accl_16_1  3D_hand_Accl_16_2  3D_hand_Accl_16_3  \
0                -8.52981           4.712060           0.358276
1               -11.23140           2.967660           2.325040
2                -1.77987           3.716760          -7.388680
3                 4.89177          -0.216854           8.273420
4                -1.96494          -9.487270           0.889387
...                   ...                ...                ...
971431           -6.10533           3.427980           7.365140
971432           -7.87425           4.095880           4.141940
971433           -5.33359          36.979800          -3.435980
971434            2.11020          11.319200          -2.429680
971435            5.04452           0.198974           8.235820

        3D_hand_Accl_6_1  3D_hand_Accl_6_2  3D_hand_Accl_6_3  ...  \
0              -8.254460          4.955160          0.791698  ...
1             -10.353600          2.978210          2.293150  ...
2              -0.572605          3.958700         -4.197230  ...
3               5.134350         -0.344501          8.596710  ...
4              -1.802600         -9.468570          1.058310  ...
...                  ...               ...               ...  ...
971431         -6.577840          4.301450          9.142140  ...
971432         -7.704180          4.138990          4.356700  ...
971433         -3.119450         34.862600         -2.873060  ...
971434          2.211510         12.367400         -2.346000  ...
971435          5.409190          0.227261          8.444170  ...

        3D_ankle_Accl_6_1  3D_ankle_Accl_6_2  3D_ankle_Accl_6_3  \
0                9.716540          -1.511980          -1.006870
1               11.137500          -1.301760          -2.513480
2               -4.136650          -4.006830           2.162320
3               -0.117976          -9.411680          -2.836260
4                9.187270           2.903000          -2.153400
...                   ...                ...                ...
971431          10.602400          -2.752050          -1.022720
971432           9.135820           1.192120          -3.570340
971433          11.857500           5.583830           0.381641
971434           9.890210          -0.561093          -2.660590
971435           2.514220          -9.420820           1.569270

        3D_ankleGyro_1  3D_ankleGyro_2  3D_ankleGyro_3
3D_anklemagneto_1  \
0             0.079272       -0.003718       -0.076595           -
18.7246
1            -0.276670        0.669698       -0.143689           -
51.7218
2             1.877290       -0.176273       -0.654045           -
44.6465
```

```
3             -0.008012        0.002114        0.017758           -
17.3221
4              0.010209        0.011341        0.028921           -
19.4371
...                ...             ...             ...
...
971431         0.154275        0.059888        0.106166           -
41.1119
971432         0.063705        0.008307        0.002250           -
85.4454
971433        -1.355570        1.238730       -3.278750           -
51.4954
971434         0.426933       -0.741163        0.191537           -
33.2568
971435        -0.070824        0.009968        0.010577           -
21.4016

        3D_anklemagneto_2  3D_anklemagneto_3  subject_id
0                -16.87960          36.806500           2
1                 33.83850          -6.571620           1
2                -12.21680           0.272571           5
3                 26.44510          -4.782110           6
4                 15.82690          26.000300           8
...                    ...                ...         ...
971431             5.34881           8.881400           2
971432            38.14700          16.401700           1
971433            -5.78950          36.450200           2
971434            -1.96371          46.112500           7
971435            15.80880         -13.294100           4

[971436 rows x 43 columns]
```

```
ref=axis_reducer(df_correlation,'3D_hand_Accl_16_1','3D_hand_Accl_16_2
','3D_hand_Accl_16_3','Hand_Acceleration_16')
ref=axis_reducer(ref,'3D_hand_Accl_6_1','3D_hand_Accl_6_2','3D_hand_Ac
cl_6_3','Hand_Acceleration_6')
ref=axis_reducer(ref,'3D_handGyro_1','3D_handGyro_2','3D_handGyro_3','
Hand_Gyrometer')
ref=axis_reducer(ref,'3D_ankle_Accl_6_1','3D_ankle_Accl_6_2','3D_ankle
_Accl_6_3','Ankle_Acceleration')
ref=axis_reducer(ref,'3D_handmagneto_1','3D_handmagneto_2','3D_handmag
neto_3','Hand_magnetometer')
ref=axis_reducer(ref,'3D_ankle_Accl_16_1','3D_ankle_Accl_16_2','3D_ank
le_Accl_16_3','Ankle_Acceleration_16')
ref=axis_reducer(ref,'3D_ankleGyro_1','3D_ankleGyro_2','3D_ankleGyro_3
','Ankle_Gyrometer')
ref=axis_reducer(ref,'3D_anklemagneto_1','3D_anklemagneto_2','3D_ankle
magneto_3','Ankle_Magnetometer')
ref=axis_reducer(ref,'3D_chest_Accl_16_1','3D_chest_Accl_16_2','3D_che
```

```
st_Accl_16_3','Chest_Acceleration_16')
ref

        timestamp  activityID   heartrate  Temperature_hand  \
0          767.77           3   90.000000           34.1875
1         1926.37          12  167.909091           33.6875
2         3749.31          24  181.000000           33.8125
3          255.84           1   62.000000           33.4375
4          491.73           2   79.000000           34.3125
...           ...         ...         ...               ...
971431    3648.85           6  120.000000           29.7500
971432     498.44           2   92.000000           32.5625
971433    3961.26           5  139.000000           28.8750
971434     783.52          17   74.000000           33.3750
971435     192.56           1   72.000000           32.7500

        Temperature_chest  3D_chest_Accl_6_1  3D_chest_Accl_6_2  \
0                 37.5000           0.726417            9.00292
1                 36.9375           1.029990           12.11190
2                 36.4375           0.823781            7.44068
3                 35.5625           0.426480           -1.29363
4                 37.6250           0.323531            9.94835
...                   ...                ...                ...
971431            34.7500          -2.415180            3.05996
971432            34.1875           0.954195            9.73556
971433            32.2500           3.928670           22.06030
971434            36.1250           2.309780           10.08320
971435            34.7500          -0.757257            1.78800

        3D_chest_Accl_6_3  3D_chestGyro_1  3D_chestGyro_2  ...
subject_id  \
0               -3.942390       -0.032422       -0.058200  ...
2
1               -4.267670        0.197389       -0.299194  ...
1
2                1.432570        2.479190       -0.082051  ...
5
3                9.676190       -0.026513       -0.017288  ...
6
4                0.641904       -0.074353        0.035903  ...
8
...                   ...             ...             ...  ...
...
971431         -12.388600        0.063543        0.134901  ...
2
971432           0.682817       -0.018283        0.019778  ...
1
971433         -10.543100        3.670570        0.764957  ...
2
971434          -1.908610       -0.331533        1.281290  ...
```

```
7
971435           9.692280       -0.004381        0.001607  ...
4

        Hand_Acceleration_16  Hand_Acceleration_6  Hand_Gyrometer  \
0                   9.751386             9.660047        0.164967
1                  11.847243            11.014777        2.181952
2                   8.460191             5.797924        4.643583
3                   9.613840            10.019164        0.062214
4                   9.729352             9.696556        0.057963
...                      ...                  ...             ...
971431             10.162253            12.056085        0.268151
971432              9.794678             9.770694        0.041158
971433             37.520111            35.119600        2.651422
971434             11.767777            12.780731        4.275455
971435              9.659995            10.030702        0.039176

        Ankle_Acceleration  Hand_magnetometer
Ankle_Acceleration_16  \
0                 9.884888          34.928264                     9.853628

1                11.491565          48.546151                    11.880628

2                 6.151600          46.379032                     7.628115

3                 9.830463          48.484174                    10.163821

4                 9.872713          29.258687                     9.926956

...                    ...                ...                          ...

971431           11.001392          53.481398                    10.488048

971432            9.880875          56.686076                    10.033660

971433           13.112022          56.899400                    11.042984

971434           10.257184          44.155289                    10.479384

971435            9.876019          53.783521                     9.848968


        Ankle_Gyrometer  Ankle_Magnetometer  Chest_Acceleration_16
0              0.110294           44.612218              10.060474
1              0.738707           62.156053              13.478711
2              1.995762           46.288600              11.259950
3              0.019596           31.972911               9.440225
4              0.032699           36.115194               9.970973
...                 ...                 ...                    ...
```

```
971431        0.196618          42.399025              12.667246
971432        0.064284          95.000662               9.771799
971433        3.757955          63.355439              30.175062
971434        0.876516          56.887903              10.583624
971435        0.072300          29.743566               9.600552

[971436 rows x 25 columns]
```

```
ref=axis_reducer(ref,'3D_chest_Accl_6_1','3D_chest_Accl_6_2','3D_chest
_Accl_6_3','Chest_Acceleration_6')
ref=axis_reducer(ref,'3D_chestGyro_1','3D_chestGyro_2','3D_chestGyro_3
','Chest_Gyrometer')
ref=axis_reducer(ref,'3D_chestmagneto_1','3D_chestmagneto_2','3D_chest
magneto_3','Chest_Magnetometer')
ref
```

```
        timestamp  activityID   heartrate  Temperature_hand  \
0          767.77           3   90.000000           34.1875
1         1926.37          12  167.909091           33.6875
2         3749.31          24  181.000000           33.8125
3          255.84           1   62.000000           33.4375
4          491.73           2   79.000000           34.3125
...           ...         ...         ...               ...
971431    3648.85           6  120.000000           29.7500
971432     498.44           2   92.000000           32.5625
971433    3961.26           5  139.000000           28.8750
971434     783.52          17   74.000000           33.3750
971435     192.56           1   72.000000           32.7500

        Temperature_chest  Temperature_ankle  subject_id  \
0                 37.5000            34.8125           2
1                 36.9375            34.9375           1
2                 36.4375            34.1250           5
3                 35.5625            34.6250           6
4                 37.6250            33.9375           8
...                   ...                ...         ...
971431            34.7500            33.6250           2
971432            34.1875            32.9375           1
971433            32.2500            31.7500           2
971434            36.1250            32.5625           7
971435            34.7500            33.4375           4

        Hand_Acceleration_16  Hand_Acceleration_6  Hand_Gyrometer  \
0                   9.751386             9.660047        0.164967
1                  11.847243            11.014777        2.181952
2                   8.460191             5.797924        4.643583
3                   9.613840            10.019164        0.062214
4                   9.729352             9.696556        0.057963
...                      ...                  ...             ...
971431             10.162253            12.056085        0.268151
```

| | | | |
|---|---|---|---|
| 971432 | 9.794678 | 9.770694 | 0.041158 |
| 971433 | 37.520111 | 35.119600 | 2.651422 |
| 971434 | 11.767777 | 12.780731 | 4.275455 |
| 971435 | 9.659995 | 10.030702 | 0.039176 |

| | Ankle_Acceleration | Hand_magnetometer | Ankle_Acceleration_16 \ |
|---|---|---|---|
| 0 | 9.884888 | 34.928264 | 9.853628 |
| 1 | 11.491565 | 48.546151 | 11.880628 |
| 2 | 6.151600 | 46.379032 | 7.628115 |
| 3 | 9.830463 | 48.484174 | 10.163821 |
| 4 | 9.872713 | 29.258687 | 9.926956 |
| ... | ... | ... | ... |
| 971431 | 11.001392 | 53.481398 | 10.488048 |
| 971432 | 9.880875 | 56.686076 | 10.033660 |
| 971433 | 13.112022 | 56.899400 | 11.042984 |
| 971434 | 10.257184 | 44.155289 | 10.479384 |
| 971435 | 9.876019 | 53.783521 | 9.848968 |

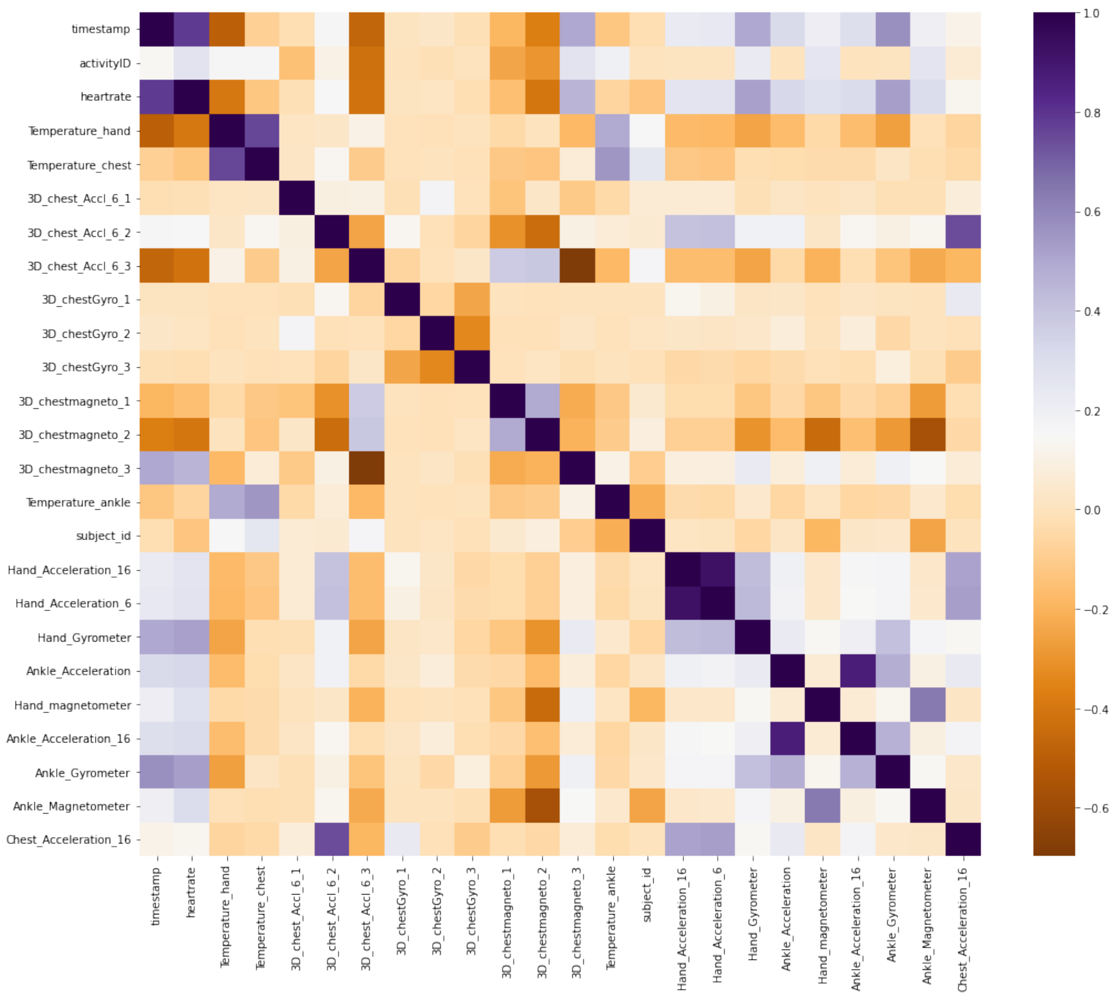
| | Ankle_Gyrometer | Ankle_Magnetometer | Chest_Acceleration_16 \ |
|---|---|---|---|
| 0 | 0.110294 | 44.612218 | 10.060474 |
| 1 | 0.738707 | 62.156053 | 13.478711 |
| 2 | 1.995762 | 46.288600 | 11.259950 |
| 3 | 0.019596 | 31.972911 | 9.440225 |
| 4 | 0.032699 | 36.115194 | 9.970973 |
| ... | ... | ... | ... |
| 971431 | 0.196618 | 42.399025 | 12.667246 |
| 971432 | 0.064284 | 95.000662 | 9.771799 |
| 971433 | 3.757955 | 63.355439 | 30.175062 |
| 971434 | 0.876516 | 56.887903 | 10.583624 |
| 971435 | 0.072300 | 29.743566 | 9.600552 |

| | Chest_Acceleration_6 | Chest_Gyrometer | Chest_Magnetometer |
|---|---|---|---|
| 0 | 9.855084 | 0.084096 | 27.869222 |
| 1 | 12.883012 | 0.474735 | 43.174891 |
| 2 | 7.621981 | 2.515189 | 49.537940 |
| 3 | 9.771592 | 0.034585 | 49.229344 |
| 4 | 9.974286 | 0.083730 | 26.310660 |

```
...                  ...         ...          ...
971431         12.987450    0.233825    41.916091
971432          9.806011    0.033836    74.998591
971433         24.763849    4.356266    53.524002
971434         10.518973    1.351819    37.290062
971435          9.884871    0.055825    49.388521

[971436 rows x 19 columns]
```

A heatmap is a visual representation of data displayed in coloured matrix form. By plotting a heatmap, we can see how much statistical similarity exists between columns. Heatmaps can be used to check whether a correlation exists between columns of a dataframe.

```
df_corr = ref.corr(method ='pearson')
df_corr = df_corr.drop(['activityID'], axis = 1)

f, ax = plt.subplots(figsize=(17, 14))
sns.heatmap(df_corr,cmap = "PuOr", mask=np.zeros_like(df_corr,
dtype=bool))
plt.show()
```



Based on the heatmap, we can conclude that Ankle_Gyrometer, 3D_chestmagneto_3, and Hand_Gyrometer are positively correlated since the value for pearson coefficient is higher, while 3D_chest_Accl_6_3 and Temperature_hand are negatively correlated.

## Hypothesis Testing

Hypothesis: "IF, the subject is performing cumbersome activities like rope jumping and running THEN average heartrate of the subject will be more than 100."

- Independent Variable : Running and rope jumping (Physical activity)
- Dependent Variable : Average Heart rate

Null Hypothesis(H0) : The average heartrate of the subject while performing running and rope jumping is less than or equal to 100 (μ <= 100).

Alternate Hypothesis(H1) :The average heartrate of the subject while performing running and rope jumping is greater than 100 (μ > 100).

```
running_data = training_data[training_data["activityID"] == 5]
ropejumping_data = training_data[training_data["activityID"] == 24]
cumbersome_data=pd.DataFrame()
cumbersome_data =
pd.concat([cumbersome_data,running_data,ropejumping_data],
ignore_index=False)
cumbersome_data
```

```
         timestamp  activityID  heartrate  Temperature_hand  \
1436799    3466.15           5      176.0           28.0625
1165461    3392.82           5      152.0           33.8125
1427969    3377.85           5      167.0           28.1875
233529     3313.29           5      173.0           30.4375
1422642    3324.58           5      145.0           28.3125
...            ...         ...        ...               ...
247533     3602.14          24      181.0           30.1875
511742     4230.05          24      179.0           28.5000
1184329    3681.75          24      139.0           33.8750
501024     4122.87          24      123.0           28.3125
237828     3505.09          24      129.0           30.1875

         3D_hand_Accl_16_1  3D_hand_Accl_16_2  3D_hand_Accl_16_3  \
1436799         -11.614500          12.199200          -5.178400
1165461          -4.625630          -4.954130           0.564829
1427969         -32.151100          54.792300          -3.820800
233529          -30.378100          53.540200           6.178220
1422642           8.240610           5.953630           1.182600
...                    ...                ...                ...
247533           -1.027870           7.147790          -4.925800
511742            0.634975          -0.968486           1.130520
1184329          -9.025420           3.777730           1.508630
```

```
501024          -0.539344        -1.067640        -10.933300
237828          -1.603240         7.814620          1.221310

         3D_hand_Accl_6_1  3D_hand_Accl_6_2  3D_hand_Accl_6_3  ...  \
1436799        -18.146800         21.783800         -6.030400  ...
1165461         -4.227810         -5.102200          0.416994  ...
1427969        -43.525800         62.126600         -3.238780  ...
233529         -35.598200         45.132200          4.914560  ...
1422642          6.741310          6.221660          1.256810  ...
...                   ...               ...               ...  ...
247533          -1.094920          6.650410         -4.489510  ...
511742           1.424530         -2.712040         -0.137652  ...
1184329         -8.812540          3.887880          1.821460  ...
501024          -0.241368          0.023247        -11.120200  ...
237828          -1.494780          7.609710          0.824271  ...

         3D_ankle_Accl_6_1  3D_ankle_Accl_6_2  3D_ankle_Accl_6_3  \
1436799          24.685000          12.452400          -0.480484
1165461          11.119500          -5.265060          -2.954690
1427969          19.176400          13.552100          -3.073160
233529           11.916575          -2.005432          -2.950493
1422642           7.763660           0.499046          -1.139180
...                    ...                ...                ...
247533            2.476990          -2.874380          -0.615926
511742            7.196820           1.316780          -0.230692
1184329           9.242210           0.678307          -3.236270
501024            5.258980           5.559860           6.713020
237828           25.244600          -2.021600          12.276700

         3D_ankleGyro_1  3D_ankleGyro_2  3D_ankleGyro_3
3D_anklemagneto_1  \
1436799       -0.516671       -0.102250       -1.742000         -
41.216200
1165461       -0.163015       -0.412381       -3.518760         -
19.752800
1427969       -0.252656        0.118389       -2.155950         -
44.974600
233529        -0.130902        0.464649       -1.483988         -
45.024525
1422642        3.702880       -2.506820        7.659240         -
44.596100
...                 ...             ...             ...
...
247533         1.523360        0.133100        2.189300         -
51.879500
511742        -0.532160       -0.233961       -1.513260         -
38.235700
1184329       -0.143172       -0.223484       -0.306898         -
46.121900
501024        -0.230153        0.232471        2.192700         -
```

```
36.096500
237828        0.664214       0.278529       1.631470        -
65.969600

        3D_anklemagneto_2  3D_anklemagneto_3  subject_id
1436799           3.27400           28.63310           6
1165461         -35.30170           14.99560           5
1427969           5.13008           26.91570           6
233529          -50.20960           13.76705           1
1422642           2.52040           21.53050           6
...                   ...                ...         ...
247533          -34.34670           36.14870           1
511742           -1.37933           34.65590           2
1184329          19.94060            9.16550           5
501024          -12.53920           30.18710           2
237828           12.86130          -17.57140           1

[73482 rows x 43 columns]
```

```
cumbersome_mean=cumbersome_data['heartrate'].mean()
cumbersome_std=cumbersome_data['heartrate'].std()
cumbersome_count=cumbersome_data['heartrate'].count()
cumbersome_std
```

```
22.60876807693868
```

```
cumbersome_count
```

```
73482
```

```
z=(cumbersome_mean-100)/(cumbersome_std/np.sqrt(cumbersome_count))
p_value_from_normal=(1-stats.norm.cdf(z))
print('Mean from data: ',cumbersome_mean)
print ('one tail p value from normal: ', format(p_value_from_normal,
'.2f'))
#print ('one tail p value from normal: ', z)
```

```
Mean from data:  158.40277581348565
one tail p value from normal:  0.00
```

In my analysis, I will take 5% significance levels into account. Due to the p_value of 0.05 from the z-test, I will reject my null hypothesis, which is that the subject's heart rate is less than 100 while performing cumbersome activities. I will accept my alternate hypothesis that states the average heart rate of the subject when performing rope jumping and running is greater than 100.

## Modelling

By using modeling, I will be able to predict the values. My main focus will be on predicting heart rate and activity ID. In order to predict the heart rate based on the IMU readings of the chest, I will use Polynomial Regression.

```
phydata.corr()
```

```
                    timestamp  activityID  heartrate  Temperature_hand  \
timestamp            1.000000    0.143712   0.781720         -0.493674

activityID           0.143712    1.000000   0.265348          0.159352

heartrate            0.781720    0.265348   1.000000         -0.395932

Temperature_hand    -0.493674    0.159352  -0.395932          1.000000

3D_hand_Accl_16_1   -0.321940   -0.129905  -0.298458          0.059130

3D_hand_Accl_16_2    0.039321    0.038609   0.065728         -0.053288

3D_hand_Accl_16_3   -0.215706   -0.116724  -0.268278          0.077812

3D_hand_Accl_6_1    -0.332616   -0.129179  -0.307739          0.073200

3D_hand_Accl_6_2     0.036865    0.042104   0.063252         -0.048332

3D_hand_Accl_6_3    -0.226055   -0.118394  -0.277938          0.094127

3D_handGyro_1        0.011050    0.019513   0.012257         -0.025622

3D_handGyro_2        0.047300    0.027951   0.059773         -0.023345

3D_handGyro_3        0.002810    0.001211  -0.001140         -0.001049

3D_handmagneto_1     0.337544    0.053005   0.322611         -0.096713

3D_handmagneto_2    -0.095922   -0.188841  -0.134859         -0.024213

3D_handmagneto_3     0.084492   -0.023507   0.106754         -0.022195

Temperature_chest   -0.084272    0.159571  -0.127371          0.757514

3D_chest_Accl_16_1  -0.027998   -0.150098  -0.018564          0.005239

3D_chest_Accl_16_2   0.157065    0.105353   0.151197          0.034396
```

| | | | | |
|---|---|---|---|---|
| 3D_chest_Accl_16_3 | -0.469099 | -0.428336 | -0.409800 | 0.098116 |
| 3D_chest_Accl_6_1 | -0.026889 | -0.147677 | -0.018807 | 0.019417 |
| 3D_chest_Accl_6_2 | 0.158540 | 0.103335 | 0.153499 | 0.032130 |
| 3D_chest_Accl_6_3 | -0.471208 | -0.429389 | -0.412970 | 0.107511 |
| 3D_chestGyro_1 | 0.005108 | 0.000238 | 0.007120 | -0.001823 |
| 3D_chestGyro_2 | 0.025507 | -0.020597 | 0.016387 | -0.013415 |
| 3D_chestGyro_3 | -0.018143 | 0.003579 | -0.021720 | 0.004979 |
| 3D_chestmagneto_1 | -0.189442 | -0.241078 | -0.157438 | -0.043054 |
| 3D_chestmagneto_2 | -0.368725 | -0.298399 | -0.403923 | -0.001476 |
| 3D_chestmagneto_3 | 0.499251 | 0.265201 | 0.449597 | -0.180812 |
| Temperature_ankle | -0.123084 | 0.195023 | -0.062178 | 0.495376 |
| 3D_ankle_Accl_16_1 | 0.324924 | 0.133338 | 0.283501 | -0.062394 |
| 3D_ankle_Accl_16_2 | 0.200998 | 0.097188 | 0.193728 | -0.047370 |
| 3D_ankle_Accl_16_3 | 0.006021 | 0.083855 | -0.004164 | -0.041712 |
| 3D_ankle_Accl_6_1 | 0.343229 | 0.144746 | 0.297939 | -0.061476 |
| 3D_ankle_Accl_6_2 | 0.218812 | 0.103893 | 0.211036 | -0.053106 |
| 3D_ankle_Accl_6_3 | 0.003066 | 0.099199 | -0.009076 | -0.042125 |
| 3D_ankleGyro_1 | 0.001594 | -0.004876 | 0.001228 | -0.000417 |
| 3D_ankleGyro_2 | -0.045435 | 0.012900 | -0.028440 | 0.033085 |
| 3D_ankleGyro_3 | -0.001125 | 0.001905 | 0.001550 | 0.001882 |
| 3D_anklemagneto_1 | -0.308442 | -0.199631 | -0.325755 | 0.092230 |
| 3D_anklemagneto_2 | -0.234251 | -0.069626 | -0.247339 | 0.112293 |
| 3D_anklemagneto_3 | -0.041953 | 0.209897 | -0.056973 | 0.154059 |
| subject_id | -0.022949 | -0.001891 | -0.127993 | 0.154094 |

```
                    3D_hand_Accl_16_1  3D_hand_Accl_16_2  
3D_hand_Accl_16_3  \
timestamp                   -0.321940           0.039321          -
0.215706   
activityID                  -0.129905           0.038609          -
0.116724   
heartrate                   -0.298458           0.065728          -
0.268278   
Temperature_hand             0.059130          -0.053288           
0.077812   
3D_hand_Accl_16_1            1.000000          -0.085483           
0.257433   
3D_hand_Accl_16_2           -0.085483           1.000000          -
0.067639   
3D_hand_Accl_16_3            0.257433          -0.067639           
1.000000   
3D_hand_Accl_6_1             0.978695          -0.070139           
0.254849   
3D_hand_Accl_6_2            -0.080322           0.945219          -
0.067663   
3D_hand_Accl_6_3             0.261275          -0.070711           
0.964548   
3D_handGyro_1                0.020572           0.181804          -
0.028435   
3D_handGyro_2               -0.094400          -0.007236          -
0.023842   
3D_handGyro_3                0.030422           0.018463          -
0.084107   
3D_handmagneto_1            -0.509092          -0.043630          -
0.192428   
3D_handmagneto_2             0.055012          -0.430874           
0.145735   
3D_handmagneto_3            -0.210788           0.103437          -
0.506023   
Temperature_chest           -0.161275          -0.054717          -
0.030131   
3D_chest_Accl_16_1           0.020788           0.039300          -
0.102546   
3D_chest_Accl_16_2          -0.424136           0.229222          -
0.068293   
3D_chest_Accl_16_3           0.436363          -0.120776           
0.143100   
3D_chest_Accl_6_1            0.019807           0.036088          -
0.105307   
3D_chest_Accl_6_2           -0.430063           0.243264          -
0.068802   
3D_chest_Accl_6_3            0.436456          -0.127795           
0.142996   
3D_chestGyro_1              -0.071869           0.060359           
```

```
0.008060
3D_chestGyro_2            -0.048675        0.001573          -
0.058523
3D_chestGyro_3             0.080158        0.033692
0.031157
3D_chestmagneto_1          0.248302       -0.052192
0.175672
3D_chestmagneto_2          0.340194       -0.088579
0.199710
3D_chestmagneto_3         -0.343251        0.055371          -
0.136653
Temperature_ankle         -0.134254        0.074205          -
0.024140
3D_ankle_Accl_16_1        -0.284793        0.048992          -
0.158171
3D_ankle_Accl_16_2        -0.091788        0.112923          -
0.069671
3D_ankle_Accl_16_3        -0.009622        0.008100
0.019459
3D_ankle_Accl_6_1         -0.320398        0.060863          -
0.164375
3D_ankle_Accl_6_2         -0.101164        0.127373          -
0.075457
3D_ankle_Accl_6_3         -0.013885        0.007775
0.023768
3D_ankleGyro_1             0.038499       -0.004623
0.012820
3D_ankleGyro_2            -0.072116       -0.031042          -
0.011710
3D_ankleGyro_3             0.093352       -0.037152
0.023692
3D_anklemagneto_1          0.084533       -0.049024
0.060863
3D_anklemagneto_2          0.206595       -0.096015
0.108253
3D_anklemagneto_3         -0.042602        0.041010          -
0.011762
subject_id                -0.030536       -0.281382          -
0.002032

                    3D_hand_Accl_6_1  3D_hand_Accl_6_2
3D_hand_Accl_6_3  ...  \
timestamp                  -0.332616          0.036865         -
0.226055  ...
activityID                 -0.129179          0.042104         -
0.118394  ...
heartrate                  -0.307739          0.063252         -
0.277938  ...
Temperature_hand            0.073200         -0.048332
0.094127  ...
```

```
3D_hand_Accl_16_1           0.978695        -0.080322          
0.261275  ...
3D_hand_Accl_16_2          -0.070139         0.945219         -
0.070711  ...
3D_hand_Accl_16_3           0.254849        -0.067663          
0.964548  ...
3D_hand_Accl_6_1            1.000000        -0.075857          
0.258160  ...
3D_hand_Accl_6_2           -0.075857         1.000000         -
0.057245  ...
3D_hand_Accl_6_3            0.258160        -0.057245          
1.000000  ...
3D_handGyro_1               0.026733         0.127434         -
0.018062  ...
3D_handGyro_2              -0.070609        -0.018114         -
0.046556  ...
3D_handGyro_3               0.026827         0.047140         -
0.081414  ...
3D_handmagneto_1           -0.513296        -0.042100         -
0.193052  ...
3D_handmagneto_2            0.054776        -0.448265          
0.148578  ...
3D_handmagneto_3           -0.212629         0.108379         -
0.508750  ...
Temperature_chest          -0.151743        -0.051863         -
0.018037  ...
3D_chest_Accl_16_1          0.022197         0.040047         -
0.100536  ...
3D_chest_Accl_16_2         -0.422319         0.225210         -
0.071394  ...
3D_chest_Accl_16_3          0.439236        -0.126056          
0.148525  ...
3D_chest_Accl_6_1           0.018233         0.038100         -
0.103556  ...
3D_chest_Accl_6_2          -0.431257         0.240070         -
0.070809  ...
3D_chest_Accl_6_3           0.439120        -0.132640          
0.147878  ...
3D_chestGyro_1             -0.056542         0.039675          
0.002391  ...
3D_chestGyro_2             -0.040470         0.004696         -
0.057784  ...
3D_chestGyro_3              0.074419         0.040766          
0.034933  ...
3D_chestmagneto_1           0.248276        -0.055658          
0.177742  ...
3D_chestmagneto_2           0.342390        -0.092798          
0.203156  ...
3D_chestmagneto_3          -0.347580         0.058728         -
0.142154  ...
```

```
Temperature_ankle          -0.127711          0.077988         -
0.014209  ...
3D_ankle_Accl_16_1         -0.279327          0.046976         -
0.162560  ...
3D_ankle_Accl_16_2         -0.090862          0.113708         -
0.071240  ...
3D_ankle_Accl_16_3         -0.009980          0.009954
0.018408  ...
3D_ankle_Accl_6_1          -0.314685          0.057046         -
0.170112  ...
3D_ankle_Accl_6_2          -0.100935          0.130811         -
0.075637  ...
3D_ankle_Accl_6_3          -0.013800          0.009622
0.021927  ...
3D_ankleGyro_1              0.039194         -0.002519
0.012257  ...
3D_ankleGyro_2             -0.070733         -0.032122         -
0.011419  ...
3D_ankleGyro_3              0.082080         -0.013802
0.025473  ...
3D_anklemagneto_1           0.085498         -0.052534
0.062323  ...
3D_anklemagneto_2           0.211722         -0.099627
0.112929  ...
3D_anklemagneto_3          -0.039436          0.043655         -
0.009647  ...
subject_id                 -0.028407         -0.299075
0.003984  ...

                    3D_ankle_Accl_6_1  3D_ankle_Accl_6_2  
3D_ankle_Accl_6_3  \
timestamp                    0.343229           0.218812
0.003066
activityID                   0.144746           0.103893
0.099199
heartrate                    0.297939           0.211036          -
0.009076
Temperature_hand            -0.061476          -0.053106          -
0.042125
3D_hand_Accl_16_1           -0.320398          -0.101164          -
0.013885
3D_hand_Accl_16_2            0.060863           0.127373
0.007775
3D_hand_Accl_16_3           -0.164375          -0.075457
0.023768
3D_hand_Accl_6_1            -0.314685          -0.100935          -
0.013800
3D_hand_Accl_6_2             0.057046           0.130811
0.009622
3D_hand_Accl_6_3            -0.170112          -0.075637
```

| | | | |
|---|---|---|---|
| 0.021927 | | | |
| 3D_handGyro_1 | 0.024639 | 0.007832 | - |
| 0.015512 | | | |
| 3D_handGyro_2 | 0.056241 | 0.011126 | - |
| 0.036083 | | | |
| 3D_handGyro_3 | -0.029619 | 0.067769 | |
| 0.040395 | | | |
| 3D_handmagneto_1 | 0.183855 | 0.133716 | |
| 0.077258 | | | |
| 3D_handmagneto_2 | -0.177566 | -0.100271 | - |
| 0.071410 | | | |
| 3D_handmagneto_3 | 0.120442 | 0.101405 | - |
| 0.025222 | | | |
| Temperature_chest | 0.117682 | 0.063606 | - |
| 0.058572 | | | |
| 3D_chest_Accl_16_1 | -0.057189 | 0.034964 | - |
| 0.077985 | | | |
| 3D_chest_Accl_16_2 | 0.350883 | 0.123827 | - |
| 0.012490 | | | |
| 3D_chest_Accl_16_3 | -0.351082 | -0.245606 | - |
| 0.150507 | | | |
| 3D_chest_Accl_6_1 | -0.056746 | 0.050902 | - |
| 0.085095 | | | |
| 3D_chest_Accl_6_2 | 0.346028 | 0.127759 | - |
| 0.008315 | | | |
| 3D_chest_Accl_6_3 | -0.332360 | -0.252244 | - |
| 0.148667 | | | |
| 3D_chestGyro_1 | -0.015835 | 0.033178 | - |
| 0.017601 | | | |
| 3D_chestGyro_2 | 0.050787 | 0.080787 | - |
| 0.015170 | | | |
| 3D_chestGyro_3 | -0.080334 | 0.067386 | |
| 0.007946 | | | |
| 3D_chestmagneto_1 | -0.277185 | -0.172659 | - |
| 0.046764 | | | |
| 3D_chestmagneto_2 | -0.376887 | -0.206097 | - |
| 0.011048 | | | |
| 3D_chestmagneto_3 | 0.274268 | 0.208268 | |
| 0.157367 | | | |
| Temperature_ankle | 0.103990 | 0.079747 | |
| 0.109705 | | | |
| 3D_ankle_Accl_16_1 | 0.865992 | 0.136564 | - |
| 0.127484 | | | |
| 3D_ankle_Accl_16_2 | 0.173266 | 0.830114 | - |
| 0.100162 | | | |
| 3D_ankle_Accl_16_3 | 0.026540 | -0.131144 | |
| 0.680237 | | | |
| 3D_ankle_Accl_6_1 | 1.000000 | 0.160784 | - |
| 0.011388 | | | |
| 3D_ankle_Accl_6_2 | 0.160784 | 1.000000 | - |

```
0.149378
3D_ankle_Accl_6_3          -0.011388          -0.149378
1.000000
3D_ankleGyro_1             -0.026946           0.119640           -
0.082210
3D_ankleGyro_2              0.019751          -0.067823
0.011974
3D_ankleGyro_3             -0.064276           0.080396           -
0.015923
3D_anklemagneto_1          -0.214861          -0.119502           -
0.034605
3D_anklemagneto_2          -0.122585          -0.055327           -
0.065216
3D_anklemagneto_3           0.125014           0.104612           -
0.024594
subject_id                  0.000232          -0.016663           -
0.165449

                    3D_ankleGyro_1  3D_ankleGyro_2  3D_ankleGyro_3  \
timestamp                 0.001594       -0.045435       -0.001125
activityID               -0.004876        0.012900        0.001905
heartrate                 0.001228       -0.028440        0.001550
Temperature_hand         -0.000417        0.033085        0.001882
3D_hand_Accl_16_1         0.038499       -0.072116        0.093352
3D_hand_Accl_16_2        -0.004623       -0.031042       -0.037152
3D_hand_Accl_16_3         0.012820       -0.011710        0.023692
3D_hand_Accl_6_1          0.039194       -0.070733        0.082080
3D_hand_Accl_6_2         -0.002519       -0.032122       -0.013802
3D_hand_Accl_6_3          0.012257       -0.011419        0.025473
3D_handGyro_1             0.029073       -0.034873        0.138108
3D_handGyro_2             0.049503        0.098756       -0.034400
3D_handGyro_3            -0.049996       -0.017408       -0.168897
3D_handmagneto_1          0.049010       -0.084133        0.055356
3D_handmagneto_2          0.072884       -0.017045        0.051156
3D_handmagneto_3          0.007752       -0.047867        0.011586
Temperature_chest        -0.001082       -0.003040        0.002490
3D_chest_Accl_16_1        0.069913       -0.042724       -0.042076
3D_chest_Accl_16_2       -0.038563        0.027827       -0.110185
3D_chest_Accl_16_3        0.012151       -0.022057        0.069666
3D_chest_Accl_6_1         0.059285       -0.031758       -0.042266
3D_chest_Accl_6_2        -0.043967        0.031758       -0.100427
3D_chest_Accl_6_3         0.011869       -0.020204        0.063494
3D_chestGyro_1            0.017133       -0.018961       -0.046690
3D_chestGyro_2            0.125529        0.066578       -0.100307
3D_chestGyro_3            0.148984       -0.126513        0.274436
3D_chestmagneto_1         0.004302        0.014061        0.000785
3D_chestmagneto_2        -0.001941        0.019354       -0.002909
3D_chestmagneto_3         0.007541        0.004453        0.002670
Temperature_ankle        -0.011002        0.008862        0.005253
3D_ankle_Accl_16_1       -0.005604       -0.049563       -0.036485
```

```
3D_ankle_Accl_16_2        0.149641       -0.052329        0.141475
3D_ankle_Accl_16_3       -0.090419       -0.070966       -0.019770
3D_ankle_Accl_6_1        -0.026946        0.019751       -0.064276
3D_ankle_Accl_6_2         0.119640       -0.067823        0.080396
3D_ankle_Accl_6_3        -0.082210        0.011974       -0.015923
3D_ankleGyro_1            1.000000       -0.066244        0.323950
3D_ankleGyro_2           -0.066244        1.000000        0.021793
3D_ankleGyro_3            0.323950        0.021793        1.000000
3D_anklemagneto_1        -0.022029        0.021425       -0.005423
3D_anklemagneto_2         0.055971       -0.028698        0.010361
3D_anklemagneto_3        -0.016857       -0.025478       -0.017639
subject_id                0.015888       -0.006887       -0.004433

                    3D_anklemagneto_1  3D_anklemagneto_2
3D_anklemagneto_3  \
timestamp                   -0.308442          -0.234251           -
0.041953
activityID                  -0.199631          -0.069626
0.209897
heartrate                   -0.325755          -0.247339           -
0.056973
Temperature_hand             0.092230           0.112293
0.154059
3D_hand_Accl_16_1            0.084533           0.206595           -
0.042602
3D_hand_Accl_16_2           -0.049024          -0.096015
0.041010
3D_hand_Accl_16_3            0.060863           0.108253           -
0.011762
3D_hand_Accl_6_1             0.085498           0.211722           -
0.039436
3D_hand_Accl_6_2            -0.052534          -0.099627
0.043655
3D_hand_Accl_6_3             0.062323           0.112929           -
0.009647
3D_handGyro_1                0.012532          -0.066293           -
0.000633
3D_handGyro_2               -0.007820          -0.003256           -
0.014572
3D_handGyro_3               -0.062962           0.128163
0.036106
3D_handmagneto_1            -0.067752          -0.293229           -
0.157725
3D_handmagneto_2             0.237363           0.152785           -
0.307834
3D_handmagneto_3             0.164784          -0.204457
0.176941
Temperature_chest            0.003403          -0.023325
0.137156
3D_chest_Accl_16_1           0.031638           0.034772
```

```
0.022563
3D_chest_Accl_16_2          -0.095474         -0.158283
0.177911
3D_chest_Accl_16_3           0.241516          0.291592          -
0.123356
3D_chest_Accl_6_1            0.029862          0.032687
0.025687
3D_chest_Accl_6_2           -0.096078         -0.163369
0.176566
3D_chest_Accl_6_3            0.241334          0.293496          -
0.120431
3D_chestGyro_1               0.011577         -0.009814          -
0.001900
3D_chestGyro_2              -0.047100          0.071318          -
0.007137
3D_chestGyro_3               0.036327         -0.013329          -
0.016635
3D_chestmagneto_1            0.173865          0.298685          -
0.561354
3D_chestmagneto_2            0.544165          0.189275          -
0.276592
3D_chestmagneto_3           -0.162404         -0.500480          -
0.100202
Temperature_ankle           -0.046966         -0.078861
0.092491
3D_ankle_Accl_16_1          -0.206725         -0.113579
0.118556
3D_ankle_Accl_16_2          -0.111039         -0.051984
0.096681
3D_ankle_Accl_16_3          -0.027784         -0.054434          -
0.020188
3D_ankle_Accl_6_1           -0.214861         -0.122585
0.125014
3D_ankle_Accl_6_2           -0.119502         -0.055327
0.104612
3D_ankle_Accl_6_3           -0.034605         -0.065216          -
0.024594
3D_ankleGyro_1              -0.022029          0.055971          -
0.016857
3D_ankleGyro_2               0.021425         -0.028698          -
0.025478
3D_ankleGyro_3              -0.005423          0.010361          -
0.017639
3D_anklemagneto_1            1.000000          0.062097          -
0.031615
3D_anklemagneto_2            0.062097          1.000000
0.020617
3D_anklemagneto_3           -0.031615          0.020617
1.000000
subject_id                   0.193853          0.105505
```

```
0.045997

                     subject_id
timestamp             -0.022949
activityID            -0.001891
heartrate             -0.127993
Temperature_hand       0.154094
3D_hand_Accl_16_1     -0.030536
3D_hand_Accl_16_2     -0.281382
3D_hand_Accl_16_3     -0.002032
3D_hand_Accl_6_1      -0.028407
3D_hand_Accl_6_2      -0.299075
3D_hand_Accl_6_3       0.003984
3D_handGyro_1         -0.027199
3D_handGyro_2          0.004104
3D_handGyro_3         -0.001531
3D_handmagneto_1       0.050043
3D_handmagneto_2       0.307351
3D_handmagneto_3       0.031566
Temperature_chest      0.250471
3D_chest_Accl_16_1     0.054456
3D_chest_Accl_16_2     0.055383
3D_chest_Accl_16_3     0.160612
3D_chest_Accl_6_1      0.061794
3D_chest_Accl_6_2      0.054672
3D_chest_Accl_6_3      0.168062
3D_chestGyro_1        -0.001165
3D_chestGyro_2         0.014272
3D_chestGyro_3        -0.012408
3D_chestmagneto_1      0.047993
3D_chestmagneto_2      0.084797
3D_chestmagneto_3     -0.096166
Temperature_ankle     -0.215867
3D_ankle_Accl_16_1     0.002171
3D_ankle_Accl_16_2    -0.015104
3D_ankle_Accl_16_3    -0.142385
3D_ankle_Accl_6_1      0.000232
3D_ankle_Accl_6_2     -0.016663
3D_ankle_Accl_6_3     -0.165449
3D_ankleGyro_1         0.015888
3D_ankleGyro_2        -0.006887
3D_ankleGyro_3        -0.004433
3D_anklemagneto_1      0.193853
3D_anklemagneto_2      0.105505
3D_anklemagneto_3      0.045997
subject_id             1.000000

[43 rows x 43 columns]
```

## Polynomial Regression

Polynomial regression models the relationship between a dependent and independent variable as an nth-degree polynomial. Data points that do not fit linear regression is analyzed using polynomial regression. We calculated the correlation between the columns of the dataframe in the above section. As a result of the dataframe observed above, we can conclude that heartrate has a higher correlation with 3D_chest_Accl_16_2, 3D_chestmagneto_3 respectively. Hence, X will be an independent variable which includes both 3D_chest_Accl_16_2 and 3D_chestmagneto_3, and tar will be the list of variables that includes heartrate as a dependent variable.

- Independent Variable : X :- Includes 3D_chest_Accl_16_2,3D_chestmagneto_3
- Dependent Variable. : tar :-Includes heartrate

The Process involves:

- Transform the independent variable X by calculating till nth degree polynomial where n=8
- Obtain train test data by applying train_test_split inbuilt function to both X and tar.
- Apply poly_reg_model.fit(X_train,y_train) for fitting the data.
- Hence the corresponding model is created.

We compute the root mean squared error and the mean squared error in order to obtain the error. I have also provided an example for the same considering two values of X from the dataframe and predicted the heart rate.

```
X=phydata[['3D_chest_Accl_16_2','3D_chestmagneto_3']]
#phytarget=phydata['heartrate']
tar = phydata['heartrate']

from sklearn.preprocessing import PolynomialFeatures
poly = PolynomialFeatures(degree=8, include_bias=False)
poly_features = poly.fit_transform(X)
X_train, X_test, y_train, y_test = train_test_split(poly_features,
tar, test_size=0.4,train_size=0.6,random_state=4798)

from sklearn.linear_model import LinearRegression
poly_reg_model = LinearRegression()
poly_reg_model.fit(X_train, y_train)

LinearRegression()

poly_reg_y_predicted = poly_reg_model.predict(X_test)
from sklearn.metrics import mean_squared_error
poly_reg_rmse = np.sqrt(mean_squared_error(y_test,
poly_reg_y_predicted))
print('The root mean squared error is {}'.format(poly_reg_rmse))
poly_mse=mean_squared_error(y_test, poly_reg_y_predicted)
print('The mean squared error is {}'.format(poly_mse))
poly_feat = poly.fit_transform([[1.930140,-54.463000]])
```

```
predict_heart= poly_reg_model.predict(poly_feat)
predict_heart
```

```
The root mean squared error is 21.549188895804267
The mean squared error is 464.3675420670539
```

```
array([93.95065891])
```

### Random Forest Algorithm

The Random Forest algorithm can be used for both classification and regression, making it extremely versatile. As the name implies, Random Forest is a forest of trees, decision trees that are randomly populated. The algorithms create and combine decision trees, and the more trees in the forest, the better the accuracy of the predictions. The process includes:-

- A dataframe data created by dropping activityID and timestamp and target which includes activityID
- Train test data split is done for both data and target
- Import RandomForestClassifier and create a gaussian classifier clf and train the model
- Obtain the root mean sqaured error
- Accuracy of the model is also obtained

```
data=phydata.drop(['activityID','timestamp'], axis=1)
target = phydata['activityID']
train_data,test_data,train_target,test_target =
cross_validation.train_test_split(data,target,test_size=0.4,train_size
=0.6,random_state=12345)
```

```
from sklearn.ensemble import RandomForestClassifier

#Create a Gaussian Classifier
clf=RandomForestClassifier(n_estimators=100)

#Train the model using the training sets y_pred=clf.predict(X_test)
clf.fit(train_data,train_target)

y_pred=clf.predict(test_data)

rand_rmse = np.sqrt(mean_squared_error(test_target, y_pred))
print('The root mean squared error for Random Forest Classifier is
{}'.format(rand_rmse))
```

```
The root mean squared error for Random Forest Classifier is
0.12492301228595215
```

```
from sklearn import metrics
# Model Accuracy shows how often is the classifier correct?
print("Accuracy:",metrics.accuracy_score(test_target, y_pred))
```

```
Accuracy: 0.9998250013832611
```

```
tes=phydata[phydata['subject_id']==3]
tes
```

```
        timestamp  activityID   heartrate  Temperature_hand  \
513306     166.11           1  142.600000           31.0000   
513307     166.12           1  134.000000           31.0000   
513308     166.13           1  125.400000           31.0000   
513309     166.14           1  116.800000           31.0000   
513310     166.15           1  108.200000           31.0000   
...           ...         ...         ...               ...   
687639    2443.15           4  122.000000           28.6875   
687640    2443.16           4  122.000000           28.6875   
687641    2443.17           4  122.000000           28.6875   
687642    2443.18           4  122.000000           28.6875   
687643    2443.19           4  120.545455           28.6875   

        3D_hand_Accl_16_1  3D_hand_Accl_16_2  3D_hand_Accl_16_3  \
513306           -1.43105            5.40588           7.774870   
513307           -1.57471            5.14382           8.043010   
513308           -1.88156            4.50119           8.040590   
513309           -1.84377            4.50090           8.041150   
513310           -1.78781            5.18687           8.424550   
...                   ...                ...                ...   
687639           -1.20135            9.90925          -1.781750   
687640           -1.23218            9.94916          -1.589910   
687641           -1.34154            9.95104          -1.476090   
687642           -1.02451            9.95240          -1.047990   
687643           -1.16711            9.65274          -0.741214   

        3D_hand_Accl_6_1  3D_hand_Accl_6_2  3D_hand_Accl_6_3  ...  \
513306          -1.25869           5.42474           7.86577  ...   
513307          -1.42397           5.42599           7.92634  ...   
513308          -1.62143           5.06513           8.10854  ...   
513309          -1.62562           4.58187           8.09451  ...   
513310          -1.73035           4.59780           8.17008  ...   
...                  ...               ...               ...  ...   
687639          -1.26926          10.12770          -1.79391  ...   
687640          -1.30068           9.88640          -1.70274  ...   
687641          -1.28472           9.91656          -1.62732  ...   
687642          -1.28208           9.97719          -1.37075  ...   
687643          -1.18977           9.91638          -1.08379  ...   

        3D_ankle_Accl_6_1  3D_ankle_Accl_6_2  3D_ankle_Accl_6_3  \
513306            9.70353           0.999148          -0.697040   
513307            9.68799           0.953621          -0.817893   
513308            9.71766           0.968642          -0.908910   
513309            9.73190           1.074280          -1.106080   
513310            9.73166           1.134700          -1.166820   
...                   ...                ...                ...   
687639            9.89845           1.029330          -0.788984   
```

```
687640          9.77915          1.044690          -0.576507
687641          9.95965          0.954051          -0.516633
687642         10.00460          0.863293          -0.531715
687643         10.06470          0.742307          -0.531645

        3D_ankleGyro_1  3D_ankleGyro_2  3D_ankleGyro_3
3D_anklemagneto_1  \
513306       -0.201402       -0.059007        0.107266           -
43.6954
513307       -0.240913       -0.067527        0.091327           -
42.7963
513308       -0.372723       -0.060329        0.094986           -
42.8046
513309       -0.345057       -0.102539        0.114357           -
42.9115
513310       -0.435516       -0.078463        0.089137           -
42.7882
...                ...             ...             ...
...
687639       -0.157561        0.077097        0.775084           -
22.6451
687640       -0.100678        0.100662        0.740007           -
22.8618
687641       -0.064701        0.054579        0.731004           -
22.5340
687642       -0.063496        0.039095        0.730862           -
22.6406
687643       -0.005480        0.017985        0.700883           -
22.9847

        3D_anklemagneto_2  3D_anklemagneto_3  subject_id
513306           1.163090            57.3792           3
513307           0.696723            56.8717           3
513308           1.573020            57.3762           3
513309           0.921397            56.8751           3
513310           0.467699            57.4881           3
...                   ...                ...         ...
687639          -6.823270            12.4377           3
687640          -6.935700            13.1809           3
687641          -6.825550            12.3130           3
687642          -6.938610            12.8077           3
687643          -6.374950            12.8166           3

[174338 rows x 43 columns]
```

```
tes=phydata.iloc[[62117]]
tes1=tes.drop(['activityID','timestamp'], axis=1)
pred=clf.predict(tes1)
pred
```

```
array([3], dtype=int64)
```

## Summary

As a result of this report, software and hardware are designed that can quantify physical activity and provide insights based on the data. In order to achieve this, we went through several phases, including data cleaning, exploratory data analysis, hypothesis testing, and modelling. Since the data provided didn't have linear correlation, we used polynomial regression and a random forest algorithm for modeling.

As a result of this analysis, we were able to analyze each variable and derive a conclusion based on it. My analysis included heartrate, calorie burnt, a heatmap showing the correlation between the variables, and a comparison of the chest, ankle, and hand temperatures. In this analysis, we gained a greater understanding of the variables and how they relate to one another.

Other algorithms such as KNN and K-Mean can also be considered for modeling, which will also yield the desired results. The models we used are polynomial regression and the random forest algorithm which has an accuracy greater than 90% that will accurately predict the models. In conclusion, all report requirements have been met.