In [1]:
```
import pandas as pd
#import numpy as np

from TSForecasting.TsForecasting import TimeSeriesForecast
```

```
Using TensorFlow backend.
```

In [2]:
```
def testingData():
    """
    Reading Test Data
    input:
        none
    output:
        data: testing dataframe with index => DisplayTime value => GlucoseValues
    """
    #reading datasets for training
    data = pd.read_csv("~/Desktop/NCSA_genomics/Data/CGManalyzer.csv")

    diabetic_1 = data[data['ID'] == "ID01"]
    diabetic_2 = data[data['ID'] == "ID11"]
    prediabetic = data[data['ID'] == "ID21"]
    nondiabetic = data[data['ID'] == "ID29"]

#     diabetic_1 = pd.read_csv("/Users/snehgajiwala/Desktop/NCSA_genomics/Data/CGManalyzer-datasets/test/ID01.csv")
#     diabetic_2 = pd.read_csv("/Users/snehgajiwala/Desktop/NCSA_genomics/Data/CGManalyzer-datasets/test/ID11.csv")
#     prediabetic = pd.read_csv("/Users/snehgajiwala/Desktop/NCSA_genomics/Data/CGManalyzer-datasets/test/ID21.csv")
#     nondiabetic = pd.read_csv("/Users/snehgajiwala/Desktop/NCSA_genomics/Data/CGManalyzer-datasets/test/ID29.csv")

    #Converting the Display Time to 'timeStamp' so that it can be used as an index
    diabetic_1['timeStamp'] = diabetic_1['timeStamp'].apply(lambda x: pd.datetime.strptime(x, '%Y:%m:%d:%H:%M'))
    diabetic_1.drop(['ID'], axis=1, inplace=True)
    diabetic_1 = diabetic_1.set_index(['timeStamp'], drop=True)

    prediabetic['timeStamp'] = prediabetic['timeStamp'].apply(lambda x: pd.datetime.strptime(x, '%Y:%m:%d:%H:%M'))
    prediabetic.drop(['ID'], axis=1, inplace=True)
    prediabetic = prediabetic.set_index(['timeStamp'], drop=True)

    nondiabetic['timeStamp'] = nondiabetic['timeStamp'].apply(lambda x: pd.datetime.strptime(x, '%Y:%m:%d:%H:%M'))
    nondiabetic.drop(['ID'], axis=1, inplace=True)
    nondiabetic = nondiabetic.set_index(['timeStamp'], drop=True)

    diabetic_2['timeStamp'] = diabetic_2['timeStamp'].apply(lambda x: pd.datetime.strptime(x, '%Y:%m:
```

```
%d:%H:%M'))
    diabetic_2.drop(['ID'], axis=1, inplace=True)
    diabetic_2 = diabetic_2.set_index(['timeStamp'], drop=True)

    return diabetic_1, diabetic_2, prediabetic, nondiabetic
```

In [3]:
```
test_set = testingData()


#obj = TimeSeriesForecast()
#obj.connectivityTester()
```

In [ ]:
```

```

In [4]:
```
obj = TimeSeriesForecast()
```

```
============================================================
Subject ID: 1636-69-026
Status: pre-diabetic
Length of the readings: 1796
Max. Glucose value: 182
Min. Glucose value: 62
Mean Glucose value: 115.156
Missing Values: 78
Percent of missing values: 4.34%

Days: 7 days 01:29:34
============================================================
Subject ID: 1636-69-028
Status: non-diabetic
Length of the readings: 1822
Max. Glucose value: 216
Min. Glucose value: 55
Mean Glucose value: 115.385
Missing Values: 72
Percent of missing values: 3.95%

Days: 75 days 07:45:22
============================================================
Subject ID: 1636-69-032
Status: pre-diabetic
Length of the readings: 1783
Max. Glucose value: 191
Min. Glucose value: 67
Mean Glucose value: 108.316
Missing Values: 29
Percent of missing values: 1.63%

Days: 6 days 04:34:32
============================================================
Subject ID: 1636-69-035
Status: non-diabetic
Length of the readings: 2180
Max. Glucose value: 234
Min. Glucose value: 69
Mean Glucose value: 116.556
Missing Values: 137
Percent of missing values: 6.28%
```

```
Days: 11 days 01:04:20
============================================================
Subject ID: 1636-69-048
Status: non-diabetic
Length of the readings: 1779
Max. Glucose value: 144
Min. Glucose value: 63
Mean Glucose value: 97.013
Missing Values: 40
Percent of missing values: 2.25%

Days: 6 days 04:34:29
============================================================
Subject ID: 1636-69-053
Status: non-diabetic
Length of the readings: 1867
Max. Glucose value: 183
Min. Glucose value: 43
Mean Glucose value: 100.837
Missing Values: 114
Percent of missing values: 6.11%

Days: 299 days 01:32:14
============================================================
Subject ID: 1636-69-060
Status: non-diabetic
Length of the readings: 1821
Max. Glucose value: 191
Min. Glucose value: 91
Mean Glucose value: 124.349
Missing Values: 69
Percent of missing values: 3.79%

Days: 6 days 14:59:31
============================================================
Subject ID: 1636-69-064
Status: non-diabetic
Length of the readings: 1584
Max. Glucose value: 218
Min. Glucose value: 43
Mean Glucose value: 116.333
Missing Values: 91
Percent of missing values: 5.74%
```

```
Days: 5 days 16:14:32
============================================================
Subject ID: 1636-69-069
Status: non-diabetic
Length of the readings: 1897
Max. Glucose value: 187
Min. Glucose value: 69
Mean Glucose value: 108.582
Missing Values: 129
Percent of missing values: 6.8%

Days: 22 days 15:48:01
============================================================
Subject ID: 1636-69-090
Status: pre-diabetic
Length of the readings: 1863
Max. Glucose value: 195
Min. Glucose value: 54
Mean Glucose value: 108.75
Missing Values: 84
Percent of missing values: 4.51%

Days: 6 days 23:39:38
============================================================
Subject ID: 1636-69-091
Status: diabetic
Length of the readings: 1803
Max. Glucose value: 163
Min. Glucose value: 70
Mean Glucose value: 103.107
Missing Values: 92
Percent of missing values: 5.1%

Days: 6 days 10:09:39
============================================================
Subject ID: 1636-69-100
Status: non-diabetic
Length of the readings: 1880
Max. Glucose value: 153
Min. Glucose value: 41
Mean Glucose value: 97.405
Missing Values: 98
```

```
Percent of missing values: 5.21%

Days: 175 days 02:10:50
============================================================
Subject ID: 1636-69-104
Status: non-diabetic
Length of the readings: 2361
Max. Glucose value: 152
Min. Glucose value: 46
Mean Glucose value: 89.686
Missing Values: 287
Percent of missing values: 12.16%

Days: 201 days 18:23:29
============================================================
Subject ID: 1636-69-107
Status: non-diabetic
Length of the readings: 1897
Max. Glucose value: 195
Min. Glucose value: 66
Mean Glucose value: 112.329
Missing Values: 112
Percent of missing values: 5.9%

Days: 7 days 10:09:27
============================================================
Subject ID: 1636-69-111
Status: non-diabetic
Length of the readings: 1868
Max. Glucose value: 135
Min. Glucose value: 48
Mean Glucose value: 99.206
Missing Values: 94
Percent of missing values: 5.03%

Days: 21 days 00:18:50
============================================================
Subject ID: 1636-69-114
Status: pre-diabetic
Length of the readings: 1796
Max. Glucose value: 163
Min. Glucose value: 76
Mean Glucose value: 113.125
```

```
Missing Values: 57
Percent of missing values: 3.17%

Days: 6 days 06:59:31
============================================================
Subject ID: 1636-69-123
Status: non-diabetic
Length of the readings: 1905
Max. Glucose value: 138
Min. Glucose value: 49
Mean Glucose value: 86.474
Missing Values: 54
Percent of missing values: 2.83%

Days: 8 days 01:34:20
============================================================
Subject ID: 1636-70-1002
Status: non-diabetic
Length of the readings: 1794
Max. Glucose value: 168
Min. Glucose value: 57
Mean Glucose value: 99.394
Missing Values: 54
Percent of missing values: 3.01%

Days: 6 days 07:34:30
============================================================
Subject ID: 1636-70-1003
Status: non-diabetic
Length of the readings: 1895
Max. Glucose value: 146
Min. Glucose value: 46
Mean Glucose value: 90.358
Missing Values: 108
Percent of missing values: 5.7%

Days: 7 days 07:39:28
============================================================
Subject ID: 1636-70-1005
Status: pre-diabetic
Length of the readings: 1846
Max. Glucose value: 225
Min. Glucose value: 52
```

```
Mean Glucose value: 112.846
Missing Values: 71
Percent of missing values: 3.85%

Days: 8 days 03:24:24
================================================================
Subject ID: 1636-70-1008
Status: non-diabetic
Length of the readings: 1760
Max. Glucose value: 223
Min. Glucose value: 51
Mean Glucose value: 100.227
Missing Values: 54
Percent of missing values: 3.07%

Days: 6 days 04:34:32
================================================================
Subject ID: 1636-70-1010
Status: pre-diabetic
Length of the readings: 1820
Max. Glucose value: 186
Min. Glucose value: 54
Mean Glucose value: 113.984
Missing Values: 92
Percent of missing values: 5.05%

Days: 88 days 21:13:56
================================================================
Subject ID: 2133-001
Status: non-diabetic
Length of the readings: 1814
Max. Glucose value: 186
Min. Glucose value: 47
Mean Glucose value: 85.128
Missing Values: 72
Percent of missing values: 3.97%

Days: 7 days 00:59:29
================================================================
Subject ID: 2133-002
Status: non-diabetic
Length of the readings: 1806
Max. Glucose value: 163
```

```
Min. Glucose value: 60
Mean Glucose value: 94.558
Missing Values: 55
Percent of missing values: 3.05%

Days: 6 days 10:44:31
============================================================
Subject ID: 2133-003
Status: non-diabetic
Length of the readings: 1805
Max. Glucose value: 190
Min. Glucose value: 62
Mean Glucose value: 100.043
Missing Values: 30
Percent of missing values: 1.66%

Days: 6 days 07:04:28
============================================================
Subject ID: 2133-004
Status: diabetic
Length of the readings: 1776
Max. Glucose value: 246
Min. Glucose value: 61
Mean Glucose value: 126.619
Missing Values: 40
Percent of missing values: 2.25%

Days: 6 days 04:29:28
============================================================
Subject ID: 2133-006
Status: non-diabetic
Length of the readings: 1777
Max. Glucose value: 148
Min. Glucose value: 54
Mean Glucose value: 83.616
Missing Values: 54
Percent of missing values: 3.04%

Days: 6 days 04:29:35
============================================================
Subject ID: 2133-007
Status: non-diabetic
Length of the readings: 1877
```

```
Max. Glucose value: 207
Min. Glucose value: 65
Mean Glucose value: 111.021
Missing Values: 126
Percent of missing values: 6.71%

Days: 7 days 23:14:19
============================================================
Subject ID: 2133-008
Status: non-diabetic
Length of the readings: 1805
Max. Glucose value: 137
Min. Glucose value: 49
Mean Glucose value: 89.348
Missing Values: 37
Percent of missing values: 2.05%

Days: 6 days 07:34:31
============================================================
Subject ID: 2133-009
Status: non-diabetic
Length of the readings: 1781
Max. Glucose value: 183
Min. Glucose value: 59
Mean Glucose value: 109.652
Missing Values: 44
Percent of missing values: 2.47%

Days: 6 days 04:34:44
============================================================
Subject ID: 2133-010
Status: non-diabetic
Length of the readings: 1832
Max. Glucose value: 143
Min. Glucose value: 62
Mean Glucose value: 93.408
Missing Values: 80
Percent of missing values: 4.37%

Days: 6 days 17:29:32
============================================================
Subject ID: 2133-011
Status: non-diabetic
```

```
Length of the readings: 1933
Max. Glucose value: 204
Min. Glucose value: 47
Mean Glucose value: 95.197
Missing Values: 78
Percent of missing values: 4.04%

Days: 9 days 05:54:03
============================================================
Subject ID: 2133-012
Status: non-diabetic
Length of the readings: 1935
Max. Glucose value: 148
Min. Glucose value: 49
Mean Glucose value: 96.023
Missing Values: 53
Percent of missing values: 2.74%

Days: 12 days 10:14:03
============================================================
Subject ID: 2133-013
Status: non-diabetic
Length of the readings: 1960
Max. Glucose value: 206
Min. Glucose value: 41
Mean Glucose value: 96.813
Missing Values: 128
Percent of missing values: 6.53%

Days: 8 days 07:49:13
============================================================
Subject ID: 2133-015
Status: pre-diabetic
Length of the readings: 1835
Max. Glucose value: 213
Min. Glucose value: 58
Mean Glucose value: 108.779
Missing Values: 104
Percent of missing values: 5.67%

Days: 6 days 17:34:22
============================================================
Subject ID: 2133-017
```

```
Status: pre-diabetic
Length of the readings: 1799
Max. Glucose value: 182
Min. Glucose value: 68
Mean Glucose value: 109.596
Missing Values: 54
Percent of missing values: 3.0%

Days: 6 days 10:04:23
============================================================
Subject ID: 2133-018
Status: diabetic
Length of the readings: 1775
Max. Glucose value: 303
Min. Glucose value: 73
Mean Glucose value: 126.567
Missing Values: 53
Percent of missing values: 2.99%

Days: 6 days 04:39:35
============================================================
Subject ID: 2133-019
Status: pre-diabetic
Length of the readings: 1801
Max. Glucose value: 192
Min. Glucose value: 53
Mean Glucose value: 106.728
Missing Values: 87
Percent of missing values: 4.83%

Days: 9 days 04:34:17
============================================================
Subject ID: 2133-020
Status: non-diabetic
Length of the readings: 1826
Max. Glucose value: 201
Min. Glucose value: 40
Mean Glucose value: 96.927
Missing Values: 36
Percent of missing values: 1.97%

Days: 6 days 10:04:43
============================================================
```

```
Subject ID: 2133-021
Status: pre-diabetic
Length of the readings: 1797
Max. Glucose value: 236
Min. Glucose value: 62
Mean Glucose value: 130.04
Missing Values: 57
Percent of missing values: 3.17%

Days: 6 days 07:39:27
============================================================
Subject ID: 2133-022
Status: non-diabetic
Length of the readings: 1814
Max. Glucose value: 204
Min. Glucose value: 40
Mean Glucose value: 105.512
Missing Values: 81
Percent of missing values: 4.47%

Days: 6 days 12:34:33
============================================================
Subject ID: 2133-023
Status: non-diabetic
Length of the readings: 1838
Max. Glucose value: 142
Min. Glucose value: 44
Mean Glucose value: 87.567
Missing Values: 77
Percent of missing values: 4.19%

Days: 7 days 10:09:25
============================================================
Subject ID: 2133-024
Status: pre-diabetic
Length of the readings: 1821
Max. Glucose value: 180
Min. Glucose value: 41
Mean Glucose value: 99.42
Missing Values: 42
Percent of missing values: 2.31%

Days: 6 days 13:09:23
```

```
============================================================
Subject ID: 2133-025
Status: non-diabetic
Length of the readings: 1865
Max. Glucose value: 175
Min. Glucose value: 45
Mean Glucose value: 87.064
Missing Values: 61
Percent of missing values: 3.27%

Days: 6 days 18:09:38
============================================================
Subject ID: 2133-026
Status: non-diabetic
Length of the readings: 1782
Max. Glucose value: 166
Min. Glucose value: 45
Mean Glucose value: 82.692
Missing Values: 55
Percent of missing values: 3.09%

Days: 6 days 04:39:35
============================================================
Subject ID: 2133-027
Status: pre-diabetic
Length of the readings: 1936
Max. Glucose value: 155
Min. Glucose value: 60
Mean Glucose value: 91.118
Missing Values: 104
Percent of missing values: 5.37%

Days: 8 days 02:13:55
============================================================
Subject ID: 2133-028
Status: non-diabetic
Length of the readings: 1850
Max. Glucose value: 111
Min. Glucose value: 45
Mean Glucose value: 74.79
Missing Values: 58
Percent of missing values: 3.14%
```

```
Days: 7 days 02:04:30
============================================================
Subject ID: 2133-030
Status: non-diabetic
Length of the readings: 1818
Max. Glucose value: 147
Min. Glucose value: 41
Mean Glucose value: 93.2
Missing Values: 46
Percent of missing values: 2.53%

Days: 6 days 18:44:36
============================================================
Subject ID: 2133-032
Status: non-diabetic
Length of the readings: 1781
Max. Glucose value: 147
Min. Glucose value: 69
Mean Glucose value: 99.475
Missing Values: 69
Percent of missing values: 3.87%

Days: 6 days 04:34:25
============================================================
Subject ID: 2133-033
Status: non-diabetic
Length of the readings: 1892
Max. Glucose value: 161
Min. Glucose value: 49
Mean Glucose value: 92.981
Missing Values: 85
Percent of missing values: 4.49%

Days: 7 days 07:04:31
============================================================
Subject ID: 2133-035
Status: pre-diabetic
Length of the readings: 1830
Max. Glucose value: 190
Min. Glucose value: 47
Mean Glucose value: 101.771
Missing Values: 189
Percent of missing values: 10.33%
```

```
Days: 7 days 05:49:42
============================================================
Subject ID: 2133-036
Status: pre-diabetic
Length of the readings: 1954
Max. Glucose value: 214
Min. Glucose value: 58
Mean Glucose value: 107.529
Missing Values: 243
Percent of missing values: 12.44%

Days: 8 days 15:04:26
============================================================
Subject ID: 2133-037
Status: non-diabetic
Length of the readings: 1785
Max. Glucose value: 153
Min. Glucose value: 48
Mean Glucose value: 92.966
Missing Values: 77
Percent of missing values: 4.31%

Days: 6 days 07:39:25
============================================================
Subject ID: 2133-039
Status: diabetic
Length of the readings: 2013
Max. Glucose value: 204
Min. Glucose value: 50
Mean Glucose value: 103.922
Missing Values: 244
Percent of missing values: 12.12%

Days: 9 days 01:34:20
============================================================
Subject ID: 2133-040
Status: non-diabetic
Length of the readings: 1792
Max. Glucose value: 171
Min. Glucose value: 59
Mean Glucose value: 92.585
Missing Values: 91
```

```
Percent of missing values: 5.08%

Days: 6 days 10:44:37
============================================================
Subject ID: 2133-041
Status: non-diabetic
Length of the readings: 1858
Max. Glucose value: 204
Min. Glucose value: 51
Mean Glucose value: 108.56
Missing Values: 54
Percent of missing values: 2.91%

Days: 8 days 02:09:26
Train shape:  (103579, 1, 1)
Epoch 1/1
103579/103579 [==============================] - 210s 2ms/step - loss: 4.1170e-04
```

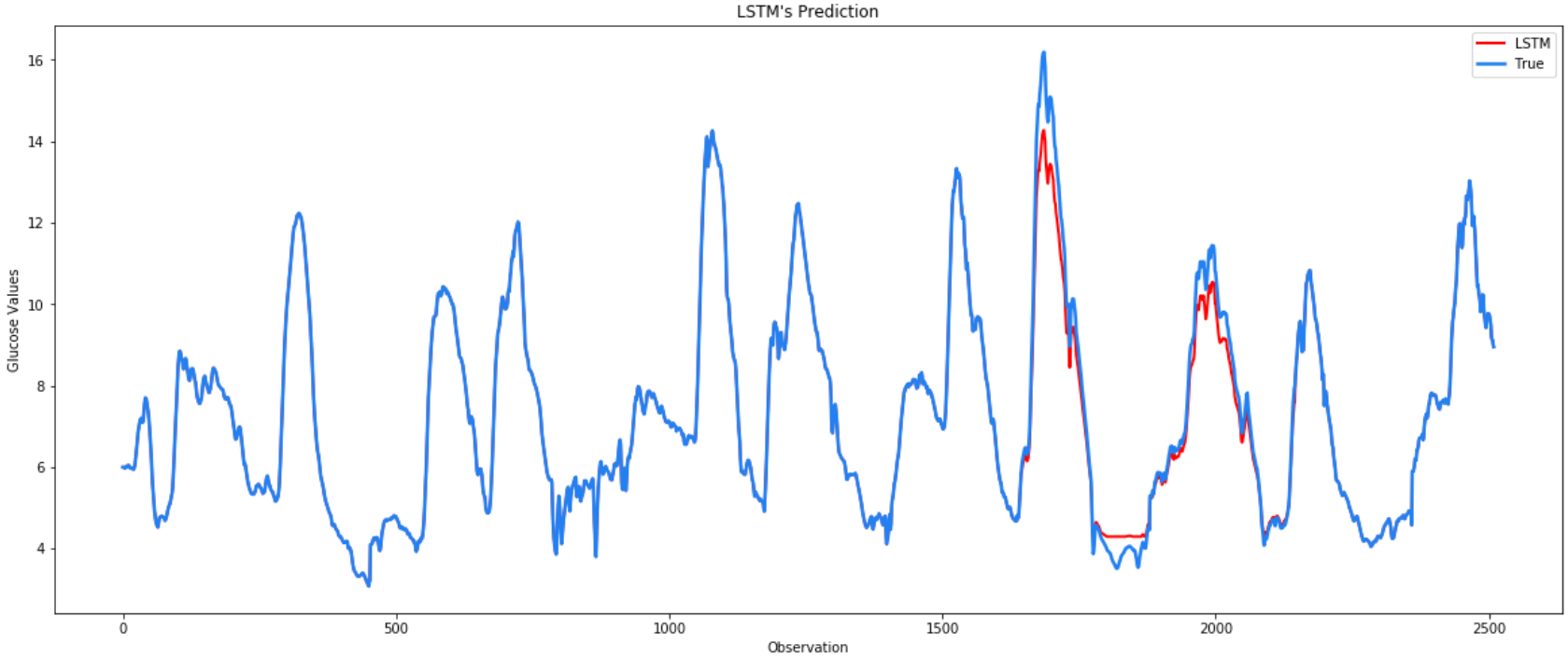
In [5]:
```
diabetic_1, diabetic_2 , prediabetic, non_diabetic = testingData()#these time series' data will be used to plot comparison graphs
diabetic_1_faulty, diabetic_2_faulty, prediabetic_faulty, non_diabetic_faulty = testingData()#gaps will be introduced in these time series' for imputations
```

In [6]:
```
start, end = obj.createGap(diabetic_1)
gap_tester_diabetic_1 = diabetic_1.iloc[start:end+2]
diabetic_1_faulty = obj.faultyData(diabetic_1_faulty,start,end+1)

#here, we're actually running the model and getting the imputed values for the gap
predicted, true = obj.testModel(gap_tester_diabetic_1)
#here we are are filling in the gap we created with imputed values generated by the model
for i in range(0,501):
     diabetic_1_faulty['glucoseValue'][start+i] = predicted[i][0]

obj.plot(diabetic_1_faulty['glucoseValue'].tolist(),diabetic_1['glucoseValue'].tolist())
obj.getMetrics(predicted,true)
diabetic_1_faulty.to_csv("~/Desktop/NCSA_genomics/Data/outputs/CGM_diabetic-1_imputed.csv")
```

```
501/501 [==============================] - 0s 798us/step
LSTM: 0.002664
```




```
Index of Agreement is: 0.988
Mean Absolute Error is: 0.47817120010315045
Root Mean Squared Error is: 0.654
Mean Absolute Difference is: [2.8893015]
Fractional Bias is: 0.06
Mean Absolute Percentage Error is: 6.0
```

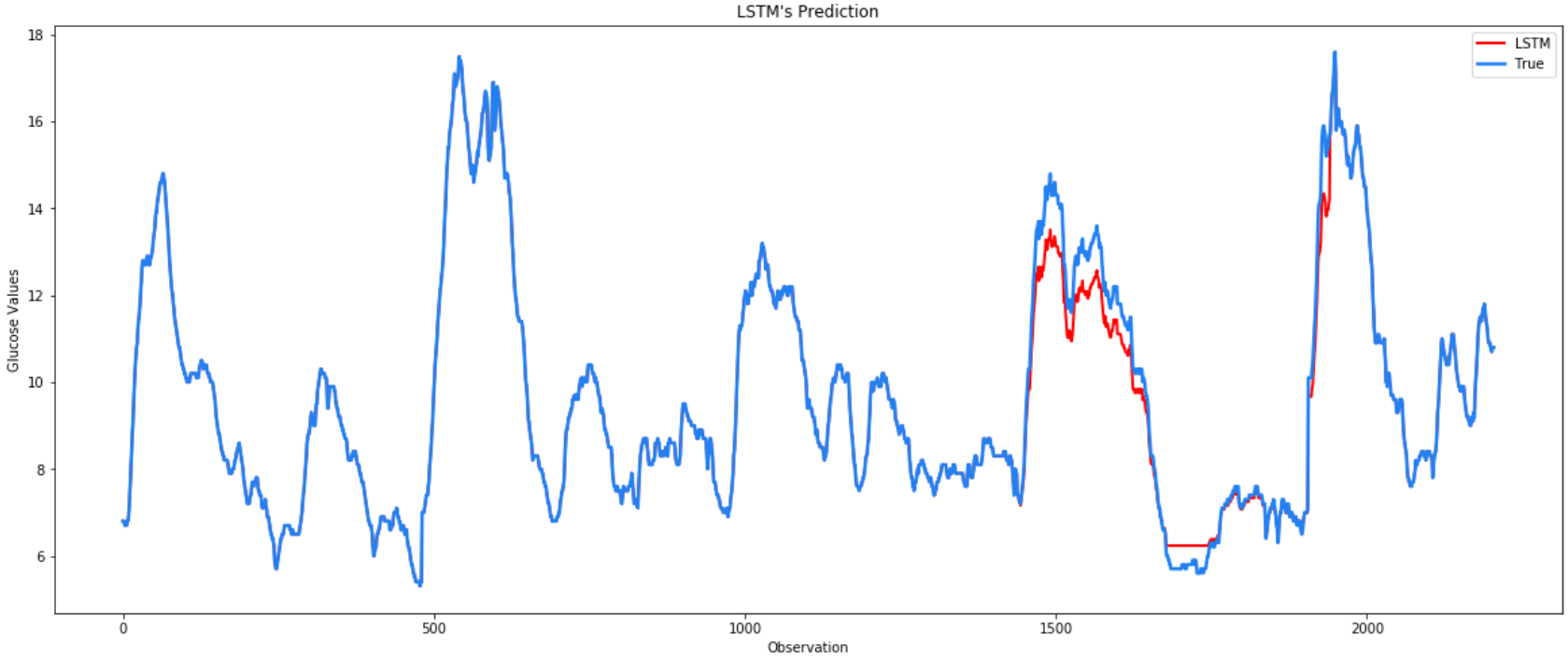
In [7]:
```
#repeating the same for diabetic type 2
start, end = obj.createGap(diabetic_2)
gap_tester_diabetic_2 = diabetic_2.iloc[start:end+2]
diabetic_2_faulty = obj.faultyData(diabetic_2_faulty,start,end+1)

predicted, true = obj.testModel(gap_tester_diabetic_2)

for i in range(0,501):
    diabetic_2_faulty['glucoseValue'][start+i] = predicted[i][0]

obj.plot(diabetic_2_faulty['glucoseValue'].tolist(),diabetic_2['glucoseValue'].tolist())
obj.getMetrics(predicted,true)
diabetic_2_faulty.to_csv("~/Desktop/NCSA_genomics/Data/outputs/CGM_diabetic-2_imputed.csv")
```

```
501/501 [==============================] - 0s 657us/step
LSTM: 0.004269
```




```
Index of Agreement is: 0.986
Mean Absolute Error is: 0.5068088034669797
Root Mean Squared Error is: 0.673
Mean Absolute Difference is: [1.8821675]
Fractional Bias is: 0.049
Mean Absolute Percentage Error is: 5.0
```

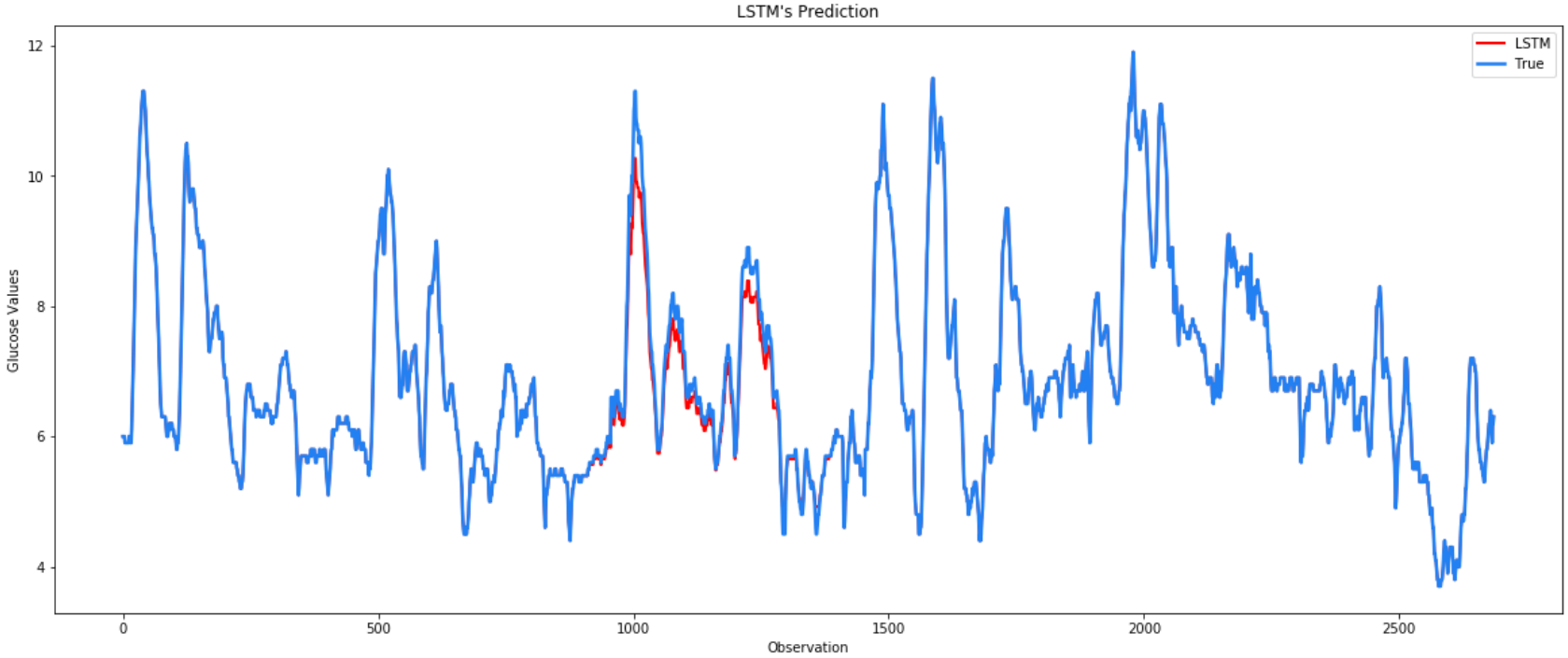
In [8]:
```
#repeating the same for prediabetic
start, end = obj.createGap(prediabetic)
gap_tester_prediabetic = prediabetic.iloc[start:end+2]
prediabetic_faulty = obj.faultyData(prediabetic_faulty,start,end+1)

predicted, true = obj.testModel(gap_tester_prediabetic)

for i in range(0,501):
    prediabetic_faulty['glucoseValue'][start+i] = predicted[i][0]

obj.plot(prediabetic_faulty['glucoseValue'].tolist(),prediabetic['glucoseValue'].tolist())
obj.getMetrics(predicted,true)
prediabetic_faulty.to_csv("~/Desktop/NCSA_genomics/Data/outputs/CGM_prediabetic_imputed.csv")
```

```
501/501 [==============================] - 0s 695us/step
LSTM: 0.002217
```




```
Index of Agreement is: 0.985
Mean Absolute Error is: 0.2297560236887065
Root Mean Squared Error is: 0.32
Mean Absolute Difference is: [1.1526821]
Fractional Bias is: 0.031
Mean Absolute Percentage Error is: 3.0
```

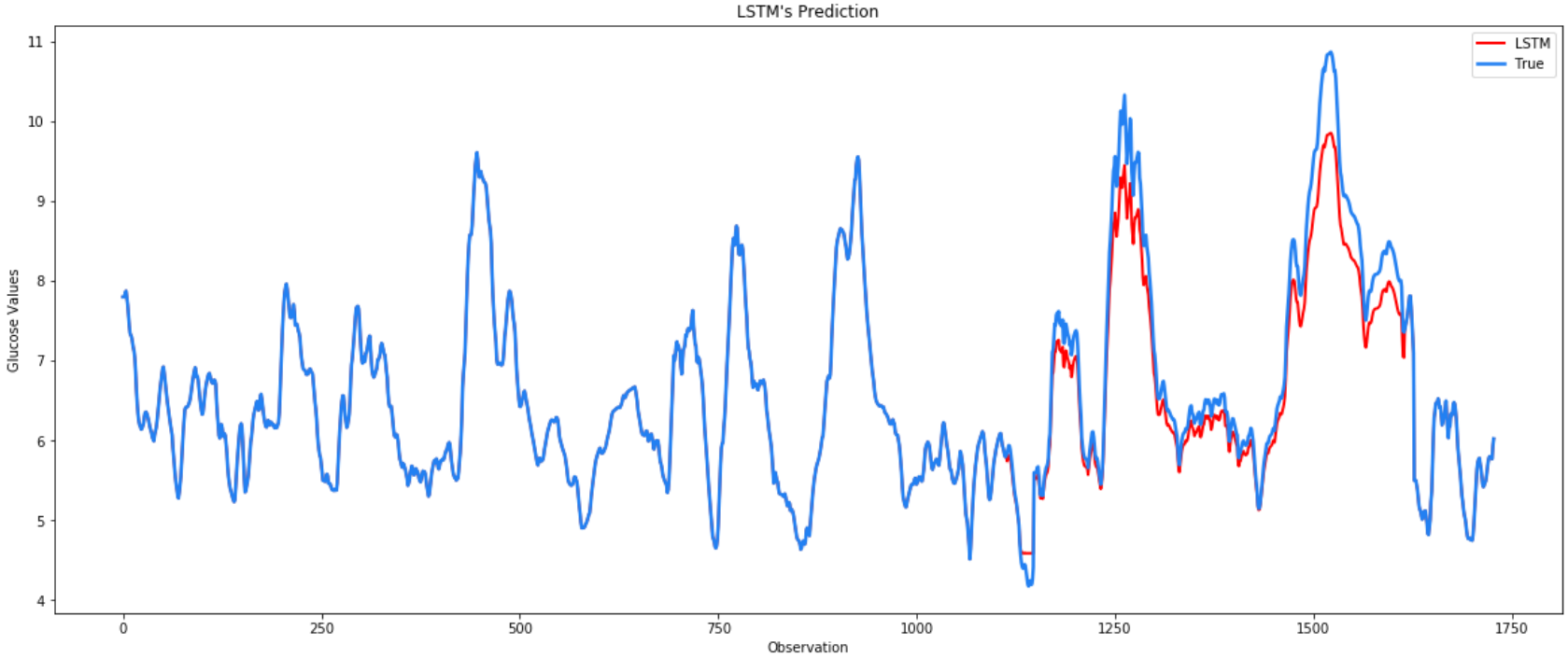
In [9]:
```
#repeating the same for non-diabetic
start, end = obj.createGap(non_diabetic)
gap_tester_non_diabetic = non_diabetic.iloc[start:end+2]
non_diabetic_faulty = obj.faultyData(non_diabetic_faulty,start,end+1)

predicted, true = obj.testModel(gap_tester_non_diabetic)

for i in range(0,501):
    non_diabetic_faulty['glucoseValue'][start+i] = predicted[i][0]

obj.plot(non_diabetic_faulty['glucoseValue'].tolist(),non_diabetic['glucoseValue'].tolist())
obj.getMetrics(predicted,true)
non_diabetic_faulty.to_csv("~/Desktop/NCSA_genomics/Data/outputs/CGM_nondiabetic_imputed.csv")
```

```
501/501 [==============================] - 0s 655us/step
LSTM: 0.004268
```




```
Index of Agreement is: 0.978
Mean Absolute Error is: 0.351251737019735
Root Mean Squared Error is: 0.437
Mean Absolute Difference is: [1.3693975]
Fractional Bias is: 0.045
Mean Absolute Percentage Error is: 4.0
```

In [ ]: