In [1]:

```python
import pandas as pd
```

In [2]:

```python
df1 = pd.read_csv('week_approach_maskedID_timeseries.csv')
```

In [3]:

```python
df1.head()
```

Out[3]:

	nr. sessions	nr. rest days	total kms	max km one day	total km Z3-Z4-Z5-T1-T2	nr. tough sessions (effort in Z5, T1 or T2)	nr. days with interval session	total km Z3-4	max km Z3-4 one day	total km Z5-T1-T2	...	max training success.2	a recovery
0	5	2	22.2	16.4	11.8	1	2	10.0	10.0	0.6	...	0.0	0.
1	5	2	21.6	16.4	11.7	1	2	10.0	10.0	0.5	...	0.0	0.
2	5	2	21.6	16.4	11.7	1	2	10.0	10.0	0.5	...	0.0	0.
3	5	2	21.6	16.4	11.7	1	2	10.0	10.0	0.5	...	0.0	0.
4	6	1	39.2	17.6	18.9	1	3	17.2	10.0	0.5	...	0.0	0.

5 rows × 72 columns

In [4]:

```python
df1.tail()
```

Out[4]:

	nr. sessions	nr. rest days	total kms	max km one day	total km Z3-Z4-Z5-T1-T2	nr. tough sessions (effort in Z5, T1 or T2)	nr. days with interval session	total km Z3-4	max km Z3-4 one day	total km Z5-T1-T2	...	max training success.2	rec
42793	4	3	59.5	19.0	0.0	0	0	0.0	0.0	0.0	...	0.80	
42794	1	6	5.8	5.8	0.0	0	0	0.0	0.0	0.0	...	0.85	
42795	3	4	38.3	16.0	0.0	0	0	0.0	0.0	0.0	...	0.93	
42796	5	2	67.0	15.1	0.0	0	0	0.0	0.0	0.0	...	0.91	
42797	4	3	45.0	12.2	0.0	0	0	0.0	0.0	0.0	...	0.88	

5 rows × 72 columns

In [5]:

```
df1.shape
```

Out[5]:

```
(42798, 72)
```

In [6]:

```
df1.columns
```

Out[6]:

```
Index(['nr. sessions', 'nr. rest days', 'total kms', 'max km one day',
       'total km Z3-Z4-Z5-T1-T2',
       'nr. tough sessions (effort in Z5, T1 or T2)',
       'nr. days with interval session', 'total km Z3-4',
       'max km Z3-4 one day', 'total km Z5-T1-T2', 'max km Z5-T1-T2 one day',
       'total hours alternative training', 'nr. strength trainings',
       'avg exertion', 'min exertion', 'max exertion', 'avg training success',
       'min training success', 'max training success', 'avg recovery',
       'min recovery', 'max recovery', 'nr. sessions.1', 'nr. rest days.1',
       'total kms.1', 'max km one day.1', 'total km Z3-Z4-Z5-T1-T2.1',
       'nr. tough sessions (effort in Z5, T1 or T2).1',
       'nr. days with interval session.1', 'total km Z3-4.1',
       'max km Z3-4 one day.1', 'total km Z5-T1-T2.1',
       'max km Z5-T1-T2 one day.1', 'total hours alternative training.1',
       'nr. strength trainings.1', 'avg exertion.1', 'min exertion.1',
       'max exertion.1', 'avg training success.1', 'min training success.1',
       'max training success.1', 'avg recovery.1', 'min recovery.1',
       'max recovery.1', 'nr. sessions.2', 'nr. rest days.2', 'total kms.2',
       'max km one day.2', 'total km Z3-Z4-Z5-T1-T2.2',
       'nr. tough sessions (effort in Z5, T1 or T2).2',
       'nr. days with interval session.2', 'total km Z3-4.2',
       'max km Z3-4 one day.2', 'total km Z5-T1-T2.2',
       'max km Z5-T1-T2 one day.2', 'total hours alternative training.2',
       'nr. strength trainings.2', 'avg exertion.2', 'min exertion.2',
       'max exertion.2', 'avg training success.2', 'min training success.2',
       'max training success.2', 'avg recovery.2', 'min recovery.2',
       'max recovery.2', 'Athlete ID', 'injury', 'rel total kms week 0_1',
       'rel total kms week 0_2', 'rel total kms week 1_2', 'Date'],
      dtype='object')
```

In [7]:

```
df1.duplicated().sum()
```

Out[7]:

```
0
```

In [8]:

```
df1.isnull().sum()
```

Out[8]:

```
nr. sessions              0
nr. rest days             0
total kms                 0
max km one day            0
total km Z3-Z4-Z5-T1-T2   0
                         ..
injury                    0
rel total kms week 0_1    0
rel total kms week 0_2    0
rel total kms week 1_2    0
Date                      0
Length: 72, dtype: int64
```

In [9]:

```
df1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 42798 entries, 0 to 42797
Data columns (total 72 columns):
 #   Column                                       Non-Null Count  Dtype  
---  ------                                       --------------  -----  
 0   nr. sessions                                 42798 non-null  int64  
 1   nr. rest days                                42798 non-null  int64  
 2   total kms                                    42798 non-null  float64
 3   max km one day                               42798 non-null  float64
 4   total km Z3-Z4-Z5-T1-T2                      42798 non-null  float64
 5   nr. tough sessions (effort in Z5, T1 or T2)  42798 non-null  int64  
 6   nr. days with interval session               42798 non-null  int64  
 7   total km Z3-4                                42798 non-null  float64
 8   max km Z3-4 one day                          42798 non-null  float64
 9   total km Z5-T1-T2                            42798 non-null  float64
 10  max km Z5-T1-T2 one day                      42798 non-null  float64
 11  total hours alternative training             42798 non-null  float64
 12  nr. strength trainings                       42798 non-null  int64  
 13  avg exertion                                 42798 non-null  float64
 14  min exertion                                 42798 non-null  float64
 15  max exertion                                 42798 non-null  float64
 16  avg training success                         42798 non-null  float64
 17  min training success                         42798 non-null  float64
 18  max training success                         42798 non-null  float64
 19  avg recovery                                 42798 non-null  float64
 20  min recovery                                 42798 non-null  float64
 21  max recovery                                 42798 non-null  float64
 22  nr. sessions.1                               42798 non-null  int64  
 23  nr. rest days.1                              42798 non-null  int64  
 24  total kms.1                                  42798 non-null  float64
 25  max km one day.1                             42798 non-null  float64
 26  total km Z3-Z4-Z5-T1-T2.1                    42798 non-null  float64
 27  nr. tough sessions (effort in Z5, T1 or T2).1 42798 non-null  int64  
 28  nr. days with interval session.1             42798 non-null  int64  
 29  total km Z3-4.1                              42798 non-null  float64
 30  max km Z3-4 one day.1                        42798 non-null  float64
 31  total km Z5-T1-T2.1                          42798 non-null  float64
 32  max km Z5-T1-T2 one day.1                    42798 non-null  float64
 33  total hours alternative training.1           42798 non-null  float64
 34  nr. strength trainings.1                     42798 non-null  int64  
 35  avg exertion.1                               42798 non-null  float64
 36  min exertion.1                               42798 non-null  float64
 37  max exertion.1                               42798 non-null  float64
 38  avg training success.1                       42798 non-null  float64
 39  min training success.1                       42798 non-null  float64
 40  max training success.1                       42798 non-null  float64
 41  avg recovery.1                               42798 non-null  float64
 42  min recovery.1                               42798 non-null  float64
 43  max recovery.1                               42798 non-null  float64
 44  nr. sessions.2                               42798 non-null  int64  
 45  nr. rest days.2                              42798 non-null  int64  
 46  total kms.2                                  42798 non-null  float64
 47  max km one day.2                             42798 non-null  float64
 48  total km Z3-Z4-Z5-T1-T2.2                    42798 non-null  float64
 49  nr. tough sessions (effort in Z5, T1 or T2).2 42798 non-null  int64  
 50  nr. days with interval session.2             42798 non-null  int64  
 51  total km Z3-4.2                              42798 non-null  float64
 52  max km Z3-4 one day.2                        42798 non-null  float64
 53  total km Z5-T1-T2.2                          42798 non-null  float64
 54  max km Z5-T1-T2 one day.2                    42798 non-null  float64
 55  total hours alternative training.2           42798 non-null  float64
 56  nr. strength trainings.2                     42798 non-null  int64  
 57  avg exertion.2                                  42798 non-null  float64
 58  min exertion.2                                  42798 non-null  float64
 59  max exertion.2                                  42798 non-null  float64
 60  avg training success.2                          42798 non-null  float64
 61  min training success.2                          42798 non-null  float64
 62  max training success.2                          42798 non-null  float64
 63  avg recovery.2                                  42798 non-null  float64
 64  min recovery.2                                  42798 non-null  float64
 65  max recovery.2                                  42798 non-null  float64
 66  Athlete ID                                      42798 non-null  int64
 67  injury                                          42798 non-null  int64
 68  rel total kms week 0_1                          42798 non-null  float64
 69  rel total kms week 0_2                          42798 non-null  float64
 70  rel total kms week 1_2                          42798 non-null  float64
 71  Date                                            42798 non-null  int64
dtypes: float64(54), int64(18)
memory usage: 23.5 MB
```

In [10]:

```
df1.describe()
```

Out[10]:

	nr. sessions	nr. rest days	total kms	max km one day	total km Z3-Z4-Z5-T1-T2	nr. tough sessions (effort in Z5, T1 or T2)	nr.
count	42798.000000	42798.000000	42798.000000	42798.000000	42798.000000	42798.000000	4279
mean	5.809337	1.874667	49.543911	14.009255	9.433621	0.930184	
std	2.484234	1.853287	36.715017	9.071678	8.887120	1.040631	
min	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
25%	5.000000	1.000000	22.800000	9.000000	1.000000	0.000000	
50%	6.000000	1.000000	44.800000	13.400000	8.000000	1.000000	
75%	7.000000	3.000000	70.100000	18.300000	14.600000	2.000000	
max	14.000000	7.000000	242.000000	131.000000	100.000000	6.000000	

8 rows × 72 columns

In [11]:

```
df1 = df1.drop(['avg training success', 'min training success', 'max training success', 'avg
               'avg training success.2', 'max training success.2', 'min training success.2',
               'avg exertion.1', 'min exertion.1', 'max exertion.1', 'avg exertion.2', 'min e
               'avg recovery', 'min recovery', 'max recovery', 'avg recovery.1', 'min recover
               'rel total kms week 0_1', 'rel total kms week 0_2', 'rel total kms week 1_2'],
```

In [12]:

```
df1.nunique()
```

Out[12]:

```
nr. sessions                                    15
nr. rest days                                    8
total kms                                     1772
total km Z3-Z4-Z5-T1-T2                        493
nr. tough sessions (effort in Z5, T1 or T2)      7
nr. days with interval session                   8
total km Z3-4                                  378
max km Z3-4 one day                            177
total km Z5-T1-T2                              317
max km Z5-T1-T2 one day                        136
total hours alternative training               679
nr. strength trainings                          10
nr. sessions.1                                  15
nr. rest days.1                                  8
total kms.1                                   1769
max km one day.1                               399
total km Z3-Z4-Z5-T1-T2.1                      494
nr. tough sessions (effort in Z5, T1 or T2).1    7
nr. days with interval session.1                 8
total km Z3-4.1                                378
max km Z3-4 one day.1                          177
total km Z5-T1-T2.1                            315
max km Z5-T1-T2 one day.1                      137
total hours alternative training.1             674
nr. strength trainings.1                        10
nr. sessions.2                                  15
nr. rest days.2                                  8
total kms.2                                   1770
max km one day.2                               396
total km Z3-Z4-Z5-T1-T2.2                      494
nr. tough sessions (effort in Z5, T1 or T2).2    7
nr. days with interval session.2                 8
total km Z3-4.2                                380
max km Z3-4 one day.2                          176
total km Z5-T1-T2.2                            311
max km Z5-T1-T2 one day.2                      138
total hours alternative training.2             691
nr. strength trainings.2                        10
Athlete ID                                      74
injury                                           2
Date                                          2614
dtype: int64
```

In [13]:

```
import matplotlib.pyplot as plt
import seaborn as sns
```

In [14]:

```
df1['injury'].unique()
```

Out[14]:

```
array([0, 1], dtype=int64)
```

In [15]:

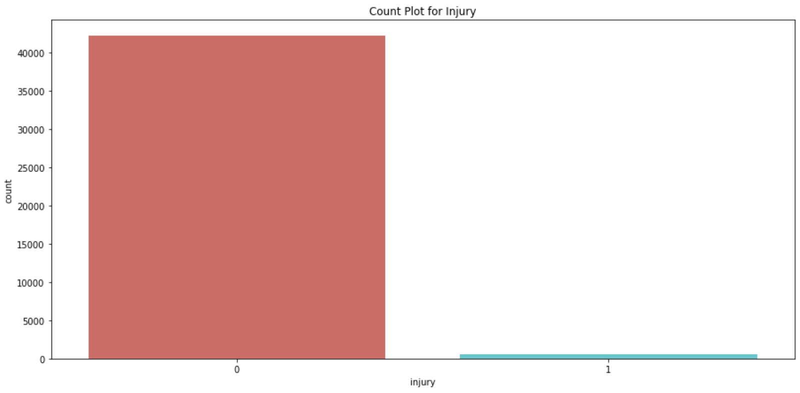
```
df1['injury'].value_counts()
```

Out[15]:

```
0    42223
1      575
Name: injury, dtype: int64
```

In [16]:

```
plt.figure(figsize=[15,7],)
plt.title('Count Plot for Injury')
sns.countplot(x = 'injury', data = df1, palette = 'hls')
plt.show()
```



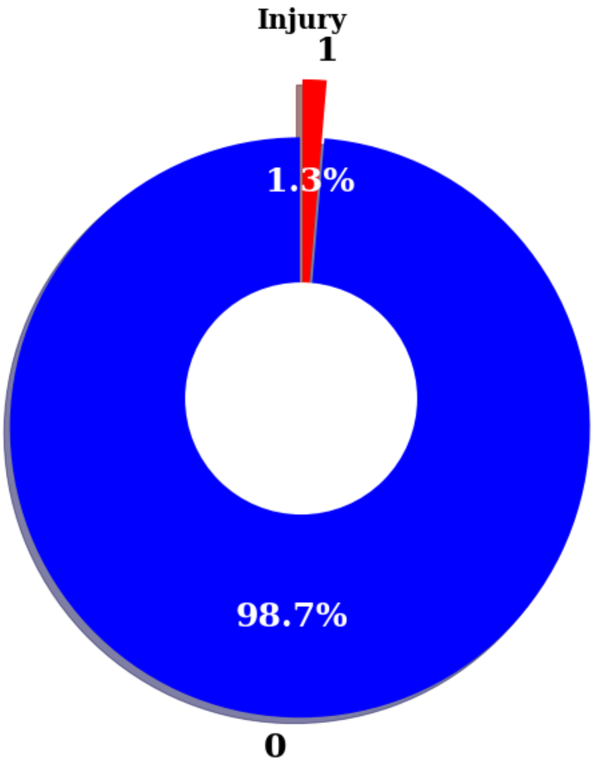
In [17]:

```
injury_data = df1['injury'].value_counts()

explode = (0.1, 0.1)
plt.figure(figsize=(14, 10))
patches, texts, pcts = plt.pie(injury_data,
                               labels = injury_data.index,
                               colors = ['blue', 'red'],
                               pctdistance = 0.65,
                               shadow = True,
                               startangle = 90,
                               explode = explode,
                               autopct = '%1.1f%%',
                               textprops={ 'fontsize': 25,
                                           'color': 'black',
                                           'weight': 'bold',
                                           'family': 'serif' })
plt.setp(pcts, color='white')

hfont = {'fontname':'serif', 'weight': 'bold'}
plt.title('Injury', size=20, **hfont)

centre_circle = plt.Circle((0,0),0.40,fc='white')
fig = plt.gcf()
fig.gca().add_artist(centre_circle)
plt.show()
```



In [18]:

```
df1['Athlete ID'].unique()
```

Out[18]:

```
array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15, 16,
       17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33,
       34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50,
       51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67,
       68, 69, 70, 71, 72, 73], dtype=int64)
```

In [19]:

```
df1['Athlete ID'].value_counts()
```

Out[19]:

```
32    1791
20    1737
22    1478
43    1471
41    1393
      ...
66     148
39     129
15     126
55      48
60      43
Name: Athlete ID, Length: 74, dtype: int64
```

In [20]:

```
df2 = df1.copy()
```

In [21]:

```
df2 = df2.set_index('Athlete ID')
```

In [22]:

```
df2.head()
```

Out[22]:

	nr. sessions	nr. rest days	total kms	total km Z3-Z4-Z5-T1-T2	nr. tough sessions (effort in Z5, T1 or T2)	nr. days with interval session	total km Z3-4	max km Z3-4 one day	total km Z5-T1-T2	max km Z5-T1-T2 one day	...	nr. tough sessions (effort in Z5, T1 or T2).2
Athlete ID												
0	5	2	22.2	11.8	1	2	10.0	10.0	0.6	0.6	...	0
0	5	2	21.6	11.7	1	2	10.0	10.0	0.5	0.5	...	0
0	5	2	21.6	11.7	1	2	10.0	10.0	0.5	0.5	...	0
0	5	2	21.6	11.7	1	2	10.0	10.0	0.5	0.5	...	0
0	6	1	39.2	18.9	1	3	17.2	10.0	0.5	0.5	...	0

5 rows × 40 columns

In [23]:

```python
df2.tail()
```

Out[23]:

Athlete ID	nr. sessions	nr. rest days	total kms	total km Z3-Z4-Z5-T1-T2	nr. tough sessions (effort in Z5, T1 or T2)	nr. days with interval session	total km Z3-4	max km Z3-4 one day	total km Z5-T1-T2	max km Z5-T1-T2 one day	...	nr. tough sessions (effort in Z5, T1 or T2).2	n i ses
71	4	3	59.5	0.0	0	0	0.0	0.0	0.0	0.0	...	0	
71	1	6	5.8	0.0	0	0	0.0	0.0	0.0	0.0	...	0	
71	3	4	38.3	0.0	0	0	0.0	0.0	0.0	0.0	...	0	
71	5	2	67.0	0.0	0	0	0.0	0.0	0.0	0.0	...	0	
71	4	3	45.0	0.0	0	0	0.0	0.0	0.0	0.0	...	0	

5 rows × 40 columns

In [24]:

```python
df2.duplicated().sum()
```

Out[24]:

```
343
```

In [25]:

```python
df2 = df2.drop_duplicates()
```

In [26]:

```
df2.isnull().sum()
```

Out[26]:

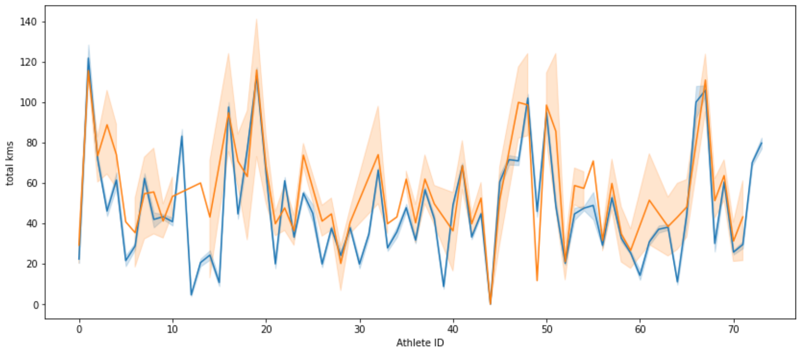
```
nr. sessions                                 0
nr. rest days                                0
total kms                                    0
total km Z3-Z4-Z5-T1-T2                      0
nr. tough sessions (effort in Z5, T1 or T2)  0
nr. days with interval session               0
total km Z3-4                                0
max km Z3-4 one day                          0
total km Z5-T1-T2                            0
max km Z5-T1-T2 one day                      0
total hours alternative training             0
nr. strength trainings                       0
nr. sessions.1                               0
nr. rest days.1                              0
total kms.1                                  0
max km one day.1                             0
total km Z3-Z4-Z5-T1-T2.1                    0
nr. tough sessions (effort in Z5, T1 or T2).1    0
nr. days with interval session.1             0
total km Z3-4.1                              0
max km Z3-4 one day.1                        0
total km Z5-T1-T2.1                          0
max km Z5-T1-T2 one day.1                    0
total hours alternative training.1           0
nr. strength trainings.1                     0
nr. sessions.2                               0
nr. rest days.2                              0
total kms.2                                  0
max km one day.2                             0
total km Z3-Z4-Z5-T1-T2.2                    0
nr. tough sessions (effort in Z5, T1 or T2).2    0
nr. days with interval session.2             0
total km Z3-4.2                              0
max km Z3-4 one day.2                        0
total km Z5-T1-T2.2                          0
max km Z5-T1-T2 one day.2                    0
total hours alternative training.2           0
nr. strength trainings.2                     0
injury                                       0
Date                                         0
dtype: int64
```

In [27]:

```
df3 = df2[df2['injury'] == 0]
df4 = df2[df2['injury'] == 1]
```

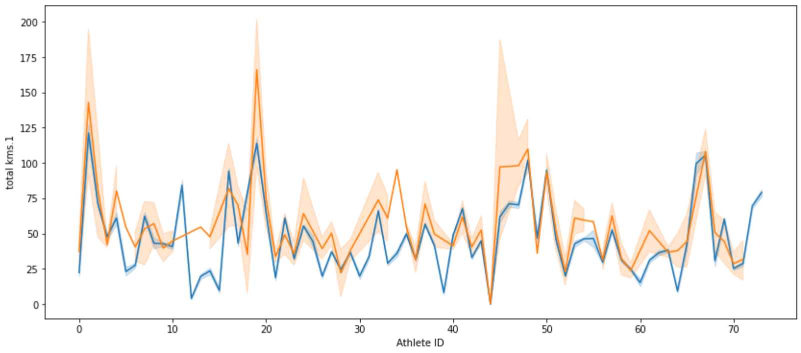
In [28]:

```
plt.figure(figsize = (14,6))
sns.lineplot(data=df3['total kms'])
sns.lineplot(data=df4['total kms'])
plt.show()
```



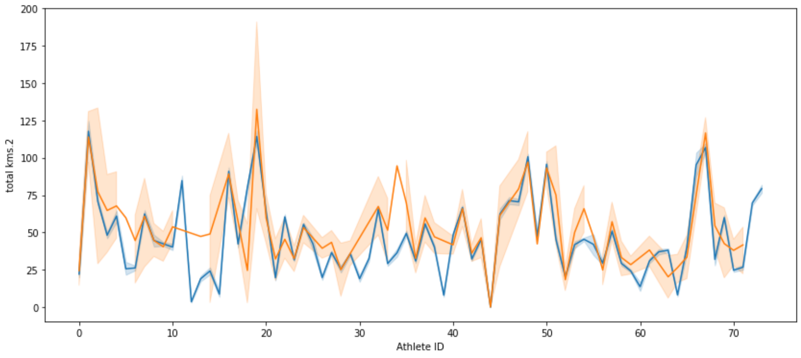
In [29]:

```
plt.figure(figsize = (14,6))
sns.lineplot(data=df3['total kms.1'])
sns.lineplot(data=df4['total kms.1'])
plt.show()
```



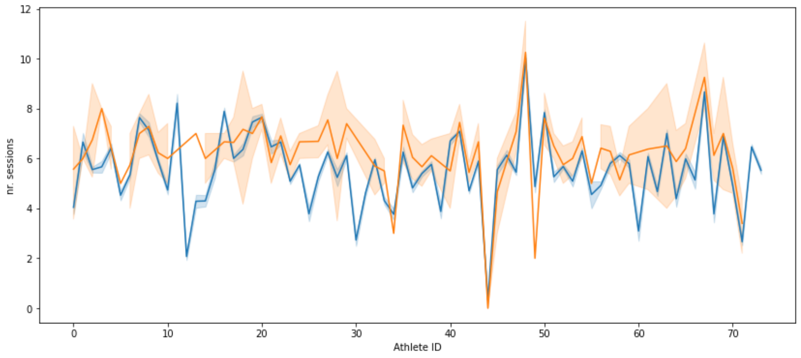
In [30]:

```
plt.figure(figsize = (14,6))
sns.lineplot(data=df3['total kms.2'])
sns.lineplot(data=df4['total kms.2'])
plt.show()
```



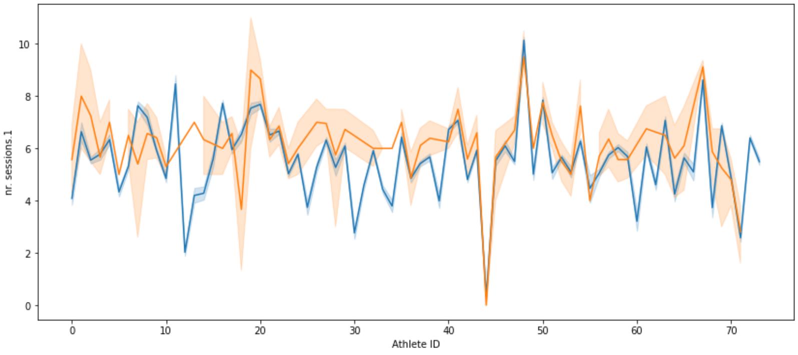
In [31]:

```
plt.figure(figsize = (14,6))
sns.lineplot(data=df3['nr. sessions'])
sns.lineplot(data=df4['nr. sessions'])
plt.show()
```



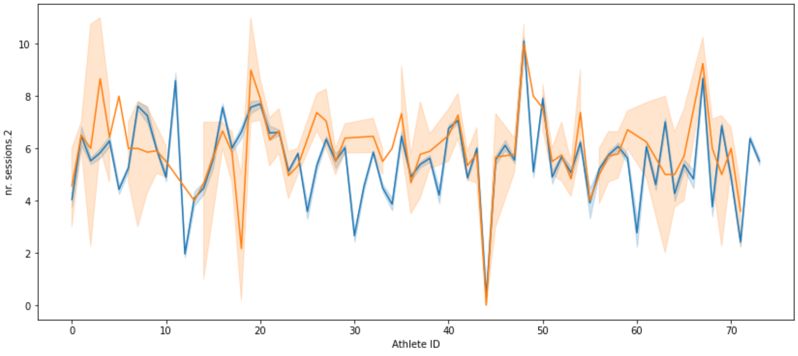
In [32]:

```
plt.figure(figsize = (14,6))
sns.lineplot(data=df3['nr. sessions.1'])
sns.lineplot(data=df4['nr. sessions.1'])
plt.show()
```



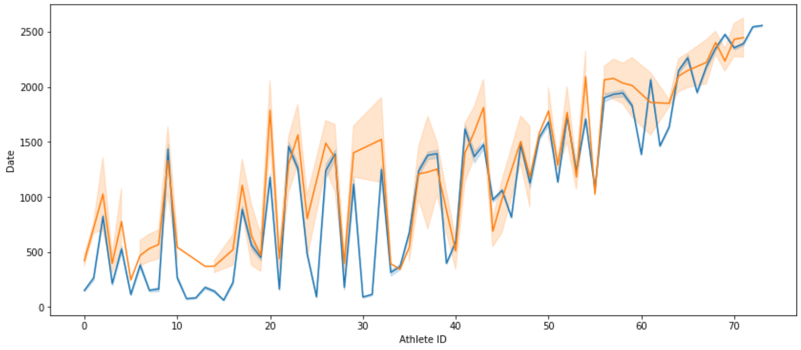
In [33]:

```
plt.figure(figsize = (14,6))
sns.lineplot(data=df3['nr. sessions.2'])
sns.lineplot(data=df4['nr. sessions.2'])
plt.show()
```



In [34]:

```
plt.figure(figsize = (14,6))
sns.lineplot(data=df3['Date'])
sns.lineplot(data=df4['Date'])
plt.show()
```



In [35]:

```
y = df2['injury']
X = df2.drop('injury', axis=1)
```

In [36]:

```
from imblearn.over_sampling import SMOTE
```

In [37]:

```
oversample = SMOTE()
X, y = oversample.fit_resample(X, y)
```

In [38]:

```
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
from sklearn.neighbors import KNeighborsClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import classification_report, confusion_matrix, accuracy_score
```

In [39]:

```
scaler = StandardScaler()
X = scaler.fit_transform(X)
```

In [40]:

```
X_train, X_test, y_train, y_test = train_test_split(X, y,
                                                    test_size = 0.3,
                                                    random_state = 0)
```

In [41]:

```
knn= KNeighborsClassifier(n_neighbors=5, metric='minkowski', p=2 )
knn.fit(X_train, y_train)
```

Out[41]:

```
▾ KNeighborsClassifier
KNeighborsClassifier()
```

In [42]:

```
y_pred_knn= knn.predict(X_test)
```

In [43]:

```
cm_knn = confusion_matrix(y_test, y_pred_knn)
```

In [44]:

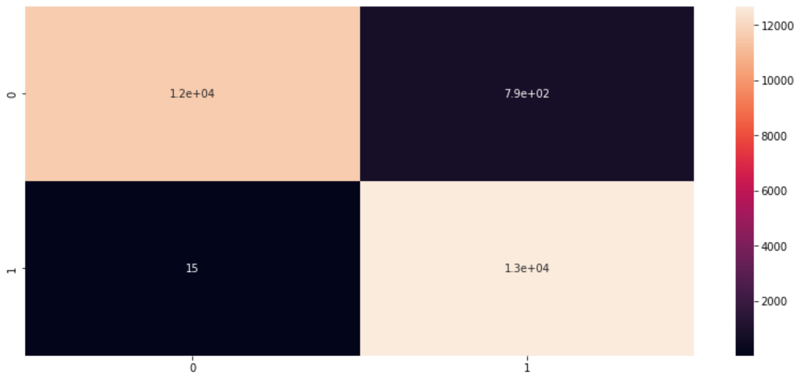
```
cm_knn
```

Out[44]:

```
array([[11635,   791],
       [   15, 12687]], dtype=int64)
```

In [45]:

```
plt.figure(figsize = (14,6))
sns.heatmap(cm_knn, annot = True)
plt.show()
```



In [46]:

```
print(classification_report(y_test, y_pred_knn))
```

```
              precision    recall  f1-score   support

           0       1.00      0.94      0.97     12426
           1       0.94      1.00      0.97     12702

    accuracy                           0.97     25128
   macro avg       0.97      0.97      0.97     25128
weighted avg       0.97      0.97      0.97     25128
```

In [47]:

```
print(accuracy_score(y_test, y_pred_knn))
```

```
0.9679242279528812
```

In [48]:

```
lr = LogisticRegression(random_state=0)
lr.fit(X_train, y_train)
```

Out[48]:

```
▾         LogisticRegression
LogisticRegression(random_state=0)
```

In [49]:

```
y_pred_lr= lr.predict(X_test)
```

In [50]:

```
cm_lr = confusion_matrix(y_test, y_pred_lr)
```

In [51]:

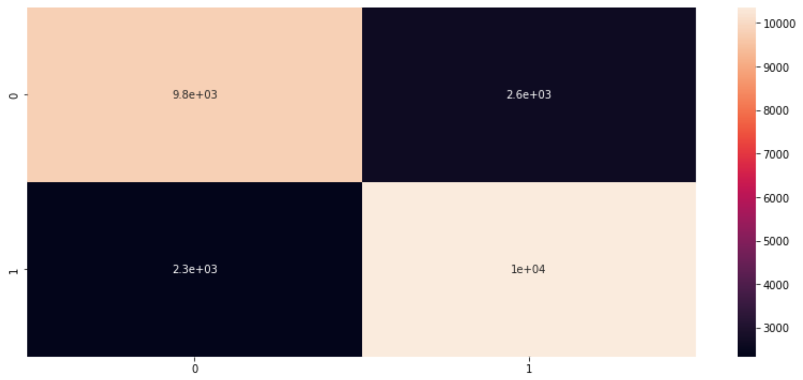
```
cm_lr
```

Out[51]:

```
array([[ 9794,  2632],
       [ 2339, 10363]], dtype=int64)
```

In [52]:

```
plt.figure(figsize = (14,6))
sns.heatmap(cm_lr, annot = True)
plt.show()
```



In [53]:

```
print(classification_report(y_test, y_pred_lr))
```

```
              precision    recall  f1-score   support

           0       0.81      0.79      0.80     12426
           1       0.80      0.82      0.81     12702

    accuracy                           0.80     25128
   macro avg       0.80      0.80      0.80     25128
weighted avg       0.80      0.80      0.80     25128
```

In [54]:

```
print(accuracy_score(y_test, y_pred_lr))
```

```
0.8021728748806113
```

In [55]:

```
rf = RandomForestClassifier(n_estimators= 10, criterion="entropy")
rf.fit(X_train, y_train)
```

Out[55]:

```
▾                    RandomForestClassifier
RandomForestClassifier(criterion='entropy', n_estimators=10)
```

In [56]:

```
y_pred_rf= rf.predict(X_test)
```

In [57]:

```
cm_rf = confusion_matrix(y_test, y_pred_rf)
```

In [58]:

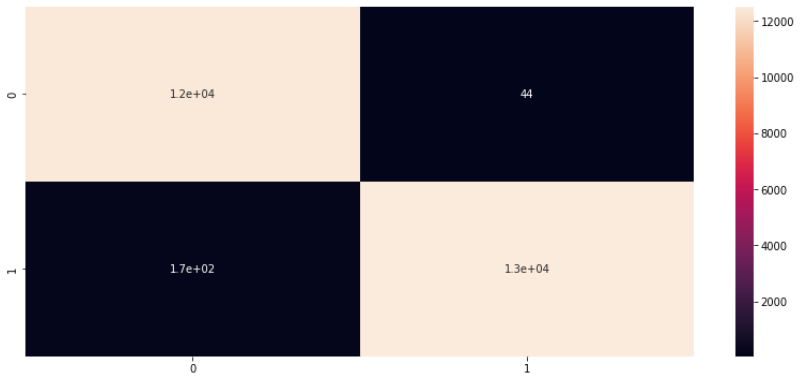
```
cm_rf
```

Out[58]:

```
array([[12382,    44],
       [  174, 12528]], dtype=int64)
```

In [59]:

```
plt.figure(figsize = (14,6))
sns.heatmap(cm_rf, annot = True)
plt.show()
```



In [60]:

```
print(classification_report(y_test, y_pred_rf))
```

```
              precision    recall  f1-score   support

           0       0.99      1.00      0.99     12426
           1       1.00      0.99      0.99     12702

    accuracy                           0.99     25128
   macro avg       0.99      0.99      0.99     25128
weighted avg       0.99      0.99      0.99     25128
```

In [61]:

```
print(accuracy_score(y_test, y_pred_rf))
```

```
0.9913244189748488
```