Analyse des Einflusses verschiedener Faktoren auf die Schlafqualität

Datenvorverarbeitung

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

# Modelle und Preprocessing
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.preprocessing import StandardScaler
from sklearn.impute import SimpleImputer

# Modellierungsalgorithmen
from sklearn.linear_model import LinearRegression
from sklearn.ensemble import RandomForestRegressor
from sklearn.tree import DecisionTreeRegressor
from sklearn.neighbors import KNeighborsRegressor
from sklearn.svm import SVR
import xgboost as xgb

# Metriken
from sklearn.metrics import mean_squared_error, r2_score,
mean_absolute_error

# Warnungen ignorieren (optional)
import warnings
warnings.filterwarnings('ignore')


# Daten einlesen
df =
pd.read_csv('../data/final_dataset_with_normalized_and_standardized_fe
atures.csv')

df.head()
```

```
   Heart_Rate_Variability  Movement_During_Sleep  Sleep_Duration_Hours
\
0               79.934283               1.324822              4.638289

1               67.234714               1.855481              6.209422

2               82.953771               1.207580              6.879592

3              100.460597               1.692038             10.331531

4               65.316933               0.106385              8.334830
```

```
   Sleep_Quality_Score  Caffeine_Intake_mg  Bedtime_Consistency  \
0                  1.0          107.624032             0.657037   
1                  1.0          104.658589             0.144464   
2                 10.0            0.000000             0.642949   
3                  1.0          116.990981             0.453255   
4                  1.0          223.282908             0.641492   

   Light_Exposure_hours  Caffeine_Squared_Smoothed  \
0              7.933949                        NaN   
1              6.992699                        NaN   
2              7.655250                        NaN   
3              9.429463                        NaN   
4             10.555713                        NaN   

   Heart_Rate_Variability_normalized  Movement_During_Sleep_normalized
...  \
0                           0.526922                          0.337521
...   
1                           0.437412                          0.413921
...   
2                           0.548204                          0.320641
...   
3                           0.671595                          0.390390
...   
4                           0.423895                          0.162099
...   

   Bedtime_Consistency_normalized  Light_Exposure_hours_normalized  \
0                        0.657037                         0.527254   
1                        0.144464                         0.462017   
2                        0.642949                         0.507937   
3                        0.453255                         0.630907   
4                        0.641492                         0.708967   

   Caffeine_Squared_Smoothed_normalized
Heart_Rate_Variability_standardized  \
0                                   NaN
0.487759   
1                                   NaN                            -
0.161022   
2                                   NaN
0.642015   
3                                   NaN
1.536382   
4                                   NaN                            -
0.258995   

   Movement_During_Sleep_standardized
Sleep_Duration_Hours_standardized  \
0                           -0.692816                          -
```

```
1.840107
1                           -0.152959                          -
0.819843
2                           -0.812090                          -
0.384647
3                           -0.319235
1.856976
4                           -1.932372
0.560356

   Caffeine_Intake_mg_standardized
Bedtime_Consistency_standardized  \
0                        -0.432369                           0.748966

1                        -0.463922                          -1.763224

2                        -1.577492                           0.679919

3                        -0.332705                          -0.249796

4                         0.798244                           0.672775


   Light_Exposure_hours_standardized
Caffeine_Squared_Smoothed_standardized
0                          -0.050799
NaN
1                          -0.516221
NaN
2                          -0.188608
NaN
3                           0.688691
NaN
4                           1.245590
NaN

[5 rows x 22 columns]
```

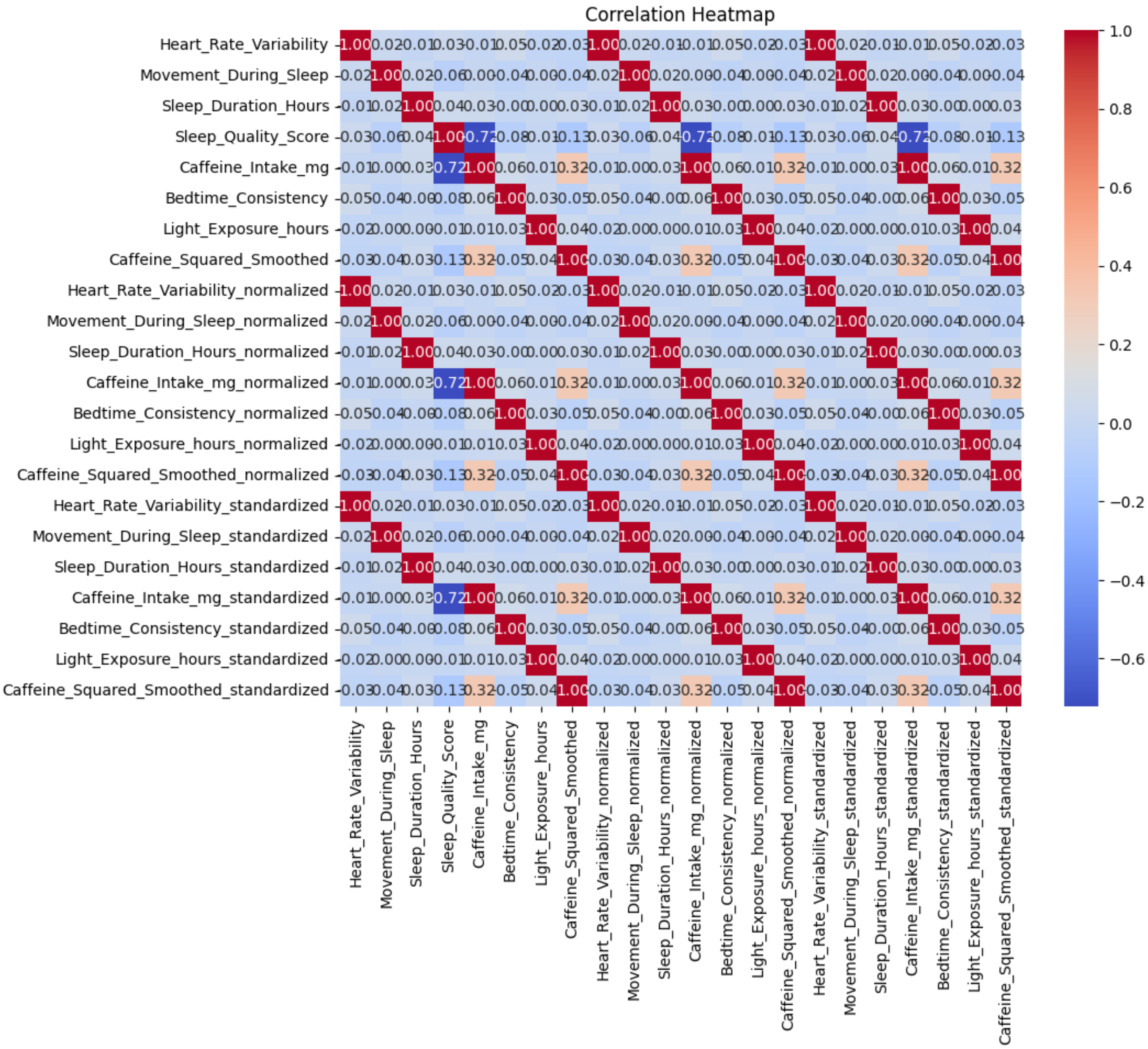
```
df.describe()
```

```
       Heart_Rate_Variability  Movement_During_Sleep
Sleep_Duration_Hours  \
count             1000.000000            1000.000000
1000.000000
mean                70.386641               2.005834
7.471921
std                 19.584319               0.983454
1.540699
min                  5.174653              -1.019512
3.105827
```

```
25%                 57.048194                1.352000
6.393869
50%                 70.506012                1.999749
7.500277
75%                 82.958878                2.660915
8.500418
max                147.054630                5.926238
12.364639

       Sleep_Quality_Score  Caffeine_Intake_mg  Bedtime_Consistency  \
count          1000.000000         1000.000000          1000.000000
mean              2.592946          148.260148             0.504222
std               2.979500           94.031760             0.204137
min               1.000000            0.000000             0.000000
25%               1.000000           80.630719             0.361569
50%               1.000000          145.717293             0.500996
75%               2.537789          211.244685             0.644680
max              10.000000          400.000000             1.000000

       Light_Exposure_hours  Caffeine_Squared_Smoothed  \
count           1000.000000                 994.000000
mean               8.036684               30886.414205
std                2.023371               11385.566159
min                0.326689                4899.711143
25%                6.726291               22980.249728
50%                8.038248               29695.445899
75%                9.354408               37353.264840
max               14.754766               76011.610684

       Heart_Rate_Variability_normalized
Movement_During_Sleep_normalized  \
count                        1000.000000
1000.000000
mean                            0.459628
0.435568
std                             0.138034
0.141591
min                             0.000000
0.000000
25%                             0.365616
0.341434
50%                             0.460469
0.434692
75%                             0.548240
0.529882
max                             1.000000
1.000000

       ...  Bedtime_Consistency_normalized
Light_Exposure_hours_normalized  \
count  ...                     1000.000000
1000.000000
mean   ...                        0.504222
0.534374
std    ...                        0.204137
0.140238
min    ...                        0.000000
0.000000
25%    ...                        0.361569
0.443552
50%    ...                        0.500996
0.534483
75%    ...                        0.644680
0.625705
max    ...                        1.000000
1.000000

       Caffeine_Squared_Smoothed_normalized  \
count                            994.000000
mean                               0.365434
std                                0.160108
min                                0.000000
25%                                0.254255
50%                                0.348686
75%                                0.456373
max                                1.000000

       Heart_Rate_Variability_standardized  \
count                         1.000000e+03
mean                         -1.119105e-16
std                           1.000500e+00
min                          -3.331472e+00
25%                          -6.814187e-01
50%                           6.098290e-03
75%                           6.422755e-01
max                           3.916723e+00

       Movement_During_Sleep_standardized
Sleep_Duration_Hours_standardized  \
count                        1.000000e+03
1.000000e+03
mean                        -1.119105e-16                      -
2.806644e-16
std                          1.000500e+00
1.000500e+00
min                         -3.077784e+00                      -
2.835258e+00
25%                         -6.651667e-01                      -
7.000663e-01
50%                         -6.190450e-03
```

```
1.841364e-02
75%                              6.664355e-01
6.678863e-01
max                              3.988355e+00
3.177238e+00

       Caffeine_Intake_mg_standardized
Bedtime_Consistency_standardized  \
count                     1.000000e+03
1.000000e+03
mean                      7.815970e-17                      1.483258e-
16
std                       1.000500e+00
1.000500e+00
min                      -1.577492e+00                      -
2.471260e+00
25%                      -7.195789e-01                     -6.991636e-
01
50%                      -2.705605e-02                     -1.581227e-
02
75%                       6.701571e-01                      6.884037e-
01
max                       2.678519e+00
2.429873e+00

       Light_Exposure_hours_standardized  \
count                       1.000000e+03
mean                       -2.451372e-16
std                         1.000500e+00
min                        -3.812377e+00
25%                        -6.479525e-01
50%                         7.735586e-04
75%                         6.515780e-01
max                         3.321904e+00

       Caffeine_Squared_Smoothed_standardized
count                                9.940000e+02
mean                                 1.072248e-16
std                                  1.000503e+00
min                                 -2.283574e+00
25%                                 -6.947520e-01
50%                                 -1.046560e-01
75%                                  5.682727e-01
max                                  3.965364e+00

[8 rows x 22 columns]

# Select only numeric columns for correlation analysis
numeric_df = df.select_dtypes(include=[np.number])
```

```python
# Generate the correlation matrix
corr_matrix = numeric_df.corr()

# Plot the heatmap
plt.figure(figsize=(10, 8))
sns.heatmap(corr_matrix, annot=True, cmap='coolwarm', fmt='.2f')
plt.title('Correlation Heatmap')
plt.show()
```



```python
# Anzahl fehlender Werte pro Spalte
print(df.isnull().sum())

# Falls fehlende Werte vorhanden sind, können wir sie entweder
entfernen oder imputieren
# Beispiel: Fehlende Werte mit dem Median ersetzen
```

```
imputer = SimpleImputer(strategy='median')
df_imputed = pd.DataFrame(imputer.fit_transform(df),
columns=df.columns)
```

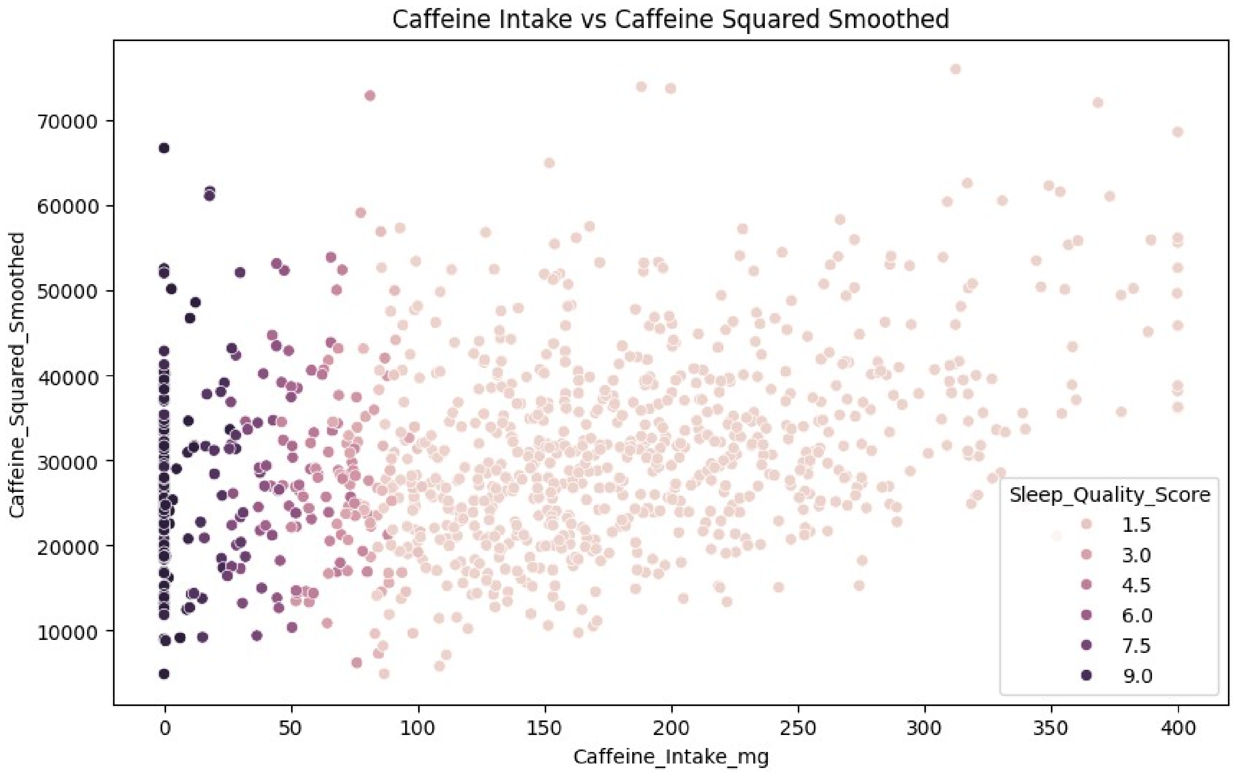
```
Heart_Rate_Variability                       0
Movement_During_Sleep                        0
Sleep_Duration_Hours                         0
Sleep_Quality_Score                          0
Caffeine_Intake_mg                           0
Bedtime_Consistency                          0
Light_Exposure_hours                         0
Caffeine_Squared_Smoothed                    6
Heart_Rate_Variability_normalized            0
Movement_During_Sleep_normalized             0
Sleep_Duration_Hours_normalized              0
Caffeine_Intake_mg_normalized                0
Bedtime_Consistency_normalized               0
Light_Exposure_hours_normalized              0
Caffeine_Squared_Smoothed_normalized         6
Heart_Rate_Variability_standardized          0
Movement_During_Sleep_standardized           0
Sleep_Duration_Hours_standardized            0
Caffeine_Intake_mg_standardized              0
Bedtime_Consistency_standardized             0
Light_Exposure_hours_standardized            0
Caffeine_Squared_Smoothed_standardized       6
dtype: int64
```

```
print(df_imputed.isnull().sum())
```

```
Heart_Rate_Variability                       0
Movement_During_Sleep                        0
Sleep_Duration_Hours                         0
Sleep_Quality_Score                          0
Caffeine_Intake_mg                           0
Bedtime_Consistency                          0
Light_Exposure_hours                         0
Caffeine_Squared_Smoothed                    0
Heart_Rate_Variability_normalized            0
Movement_During_Sleep_normalized             0
Sleep_Duration_Hours_normalized              0
Caffeine_Intake_mg_normalized                0
Bedtime_Consistency_normalized               0
Light_Exposure_hours_normalized              0
Caffeine_Squared_Smoothed_normalized         0
Heart_Rate_Variability_standardized          0
Movement_During_Sleep_standardized           0
Sleep_Duration_Hours_standardized            0
Caffeine_Intake_mg_standardized              0
Bedtime_Consistency_standardized             0
```

```
Light_Exposure_hours_standardized         0
Caffeine_Squared_Smoothed_standardized    0
dtype: int64
```

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

# Visualisierung der Beziehung zwischen Caffeine_Intake_mg und Caffeine_Squared_Smoothed
plt.figure(figsize=(10, 6))
sns.scatterplot(x='Caffeine_Intake_mg', y='Caffeine_Squared_Smoothed', hue='Sleep_Quality_Score', data=df)
plt.title('Caffeine Intake vs Caffeine Squared Smoothed')
plt.show()

# Korrelation zwischen den Caffeine-Features und Sleep_Quality_Score
correlation = df_imputed[['Caffeine_Intake_mg', 'Caffeine_Squared_Smoothed', 'Sleep_Quality_Score']].corr()
print(correlation)

# Partielle Korrelation
from scipy.stats import pearsonr

def partial_correlation(x, y, z):
    xy, _ = pearsonr(x, y)
    xz, _ = pearsonr(x, z)
    yz, _ = pearsonr(y, z)
    return (xy - xz * yz) / (((1 - xz**2) * (1 - yz**2))**0.5)

partial_corr = partial_correlation(df['Caffeine_Intake_mg'], df['Sleep_Quality_Score'], df['Caffeine_Squared_Smoothed'])
print(f"Partial correlation between Caffeine_Intake_mg and Sleep_Quality_Score, controlling for Caffeine_Squared_Smoothed: {partial_corr}")
```



```
                           Caffeine_Intake_mg
Caffeine_Squared_Smoothed  \
Caffeine_Intake_mg                   1.000000
0.322199
Caffeine_Squared_Smoothed            0.322199
1.000000
Sleep_Quality_Score                 -0.721968                  -
0.131093

                           Sleep_Quality_Score
Caffeine_Intake_mg                   -0.721968
Caffeine_Squared_Smoothed            -0.131093
Sleep_Quality_Score                   1.000000

----------------------------------------------------------------------
-----
ValueError                                Traceback (most recent call
last)
Cell In[18], line 23
     20     yz, _ = pearsonr(y, z)
     21     return (xy - xz * yz) / (((1 - xz**2) * (1 - yz**2))**0.5)
---> 23 partial_corr = partial_correlation(df['Caffeine_Intake_mg'],
df['Sleep_Quality_Score'], df['Caffeine_Squared_Smoothed'])
     24 print(f"Partial correlation between Caffeine_Intake_mg and
Sleep_Quality_Score, controlling for Caffeine_Squared_Smoothed:
{partial_corr}")
```

```
Cell In[18], line 19, in partial_correlation(x, y, z)
     17 def partial_correlation(x, y, z):
     18     xy, _ = pearsonr(x, y)
---> 19     xz, _ = pearsonr(x, z)
     20     yz, _ = pearsonr(y, z)
     21     return (xy - xz * yz) / (((1 - xz**2) * (1 - yz**2))**0.5)

File
/Library/Frameworks/Python.framework/Versions/3.10/lib/python3.10/
site-packages/scipy/stats/_stats_py.py:4794, in pearsonr(x, y,
alternative, method)
   4790 # Unlike np.linalg.norm or the expression sqrt((xm*xm).sum()),
   4791 # scipy.linalg.norm(xm) does not overflow if xm is, for
example,
   4792 # [-5e210, 5e210, 3e200, -3e200]
   4793 normxm = linalg.norm(xm)
-> 4794 normym = linalg.norm(ym)
   4796 threshold = 1e-13
   4797 if normxm < threshold*abs(xmean) or normym <
threshold*abs(ymean):
   4798     # If all the values in x (likewise y) are very close to
the mean,
   4799     # the loss of precision that occurs in the subtraction xm
= x - xmean
   4800     # might result in large errors in r.

File
/Library/Frameworks/Python.framework/Versions/3.10/lib/python3.10/
site-packages/scipy/linalg/_misc.py:146, in norm(a, ord, axis,
keepdims, check_finite)
    144 # Differs from numpy only in non-finite handling and the use
of blas.
    145 if check_finite:
--> 146     a = np.asarray_chkfinite(a)
    147 else:
    148     a = np.asarray(a)

File
/Library/Frameworks/Python.framework/Versions/3.10/lib/python3.10/
site-packages/numpy/lib/function_base.py:630, in asarray_chkfinite(a,
dtype, order)
    628 a = asarray(a, dtype=dtype, order=order)
    629 if a.dtype.char in typecodes['AllFloat'] and not
np.isfinite(a).all():
--> 630     raise ValueError(
    631         "array must not contain infs or NaNs")
    632 return a

ValueError: array must not contain infs or NaNs
```

```python
# Überprüfen Sie auf NaN oder unendliche Werte
print(df_imputed.isna().sum())
print(np.isinf(df).sum())

# Entfernen Sie Zeilen mit NaN oder unendlichen Werten
df_clean = df_imputed.replace([np.inf, -np.inf], np.nan).dropna()

# Überprüfen Sie die Größe des bereinigten Datensatzes
print(f"Originale Datengröße: {df.shape}")
print(f"Bereinigte Datengröße: {df_clean.shape}")
```

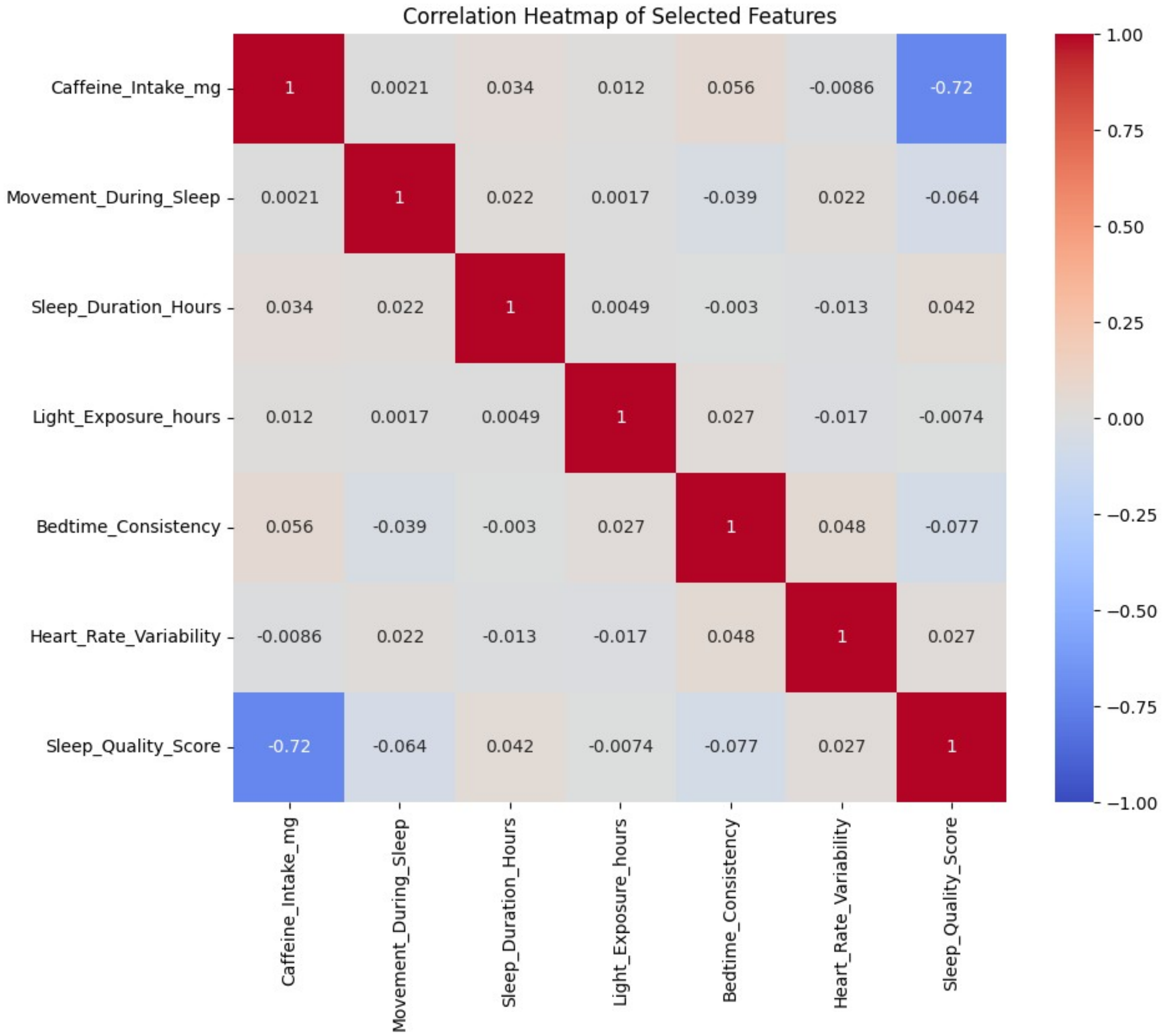
```
Heart_Rate_Variability                    0
Movement_During_Sleep                     0
Sleep_Duration_Hours                      0
Sleep_Quality_Score                       0
Caffeine_Intake_mg                        0
Bedtime_Consistency                       0
Light_Exposure_hours                      0
Caffeine_Squared_Smoothed                 0
Heart_Rate_Variability_normalized         0
Movement_During_Sleep_normalized          0
Sleep_Duration_Hours_normalized           0
Caffeine_Intake_mg_normalized             0
Bedtime_Consistency_normalized            0
Light_Exposure_hours_normalized           0
Caffeine_Squared_Smoothed_normalized      0
Heart_Rate_Variability_standardized       0
Movement_During_Sleep_standardized        0
Sleep_Duration_Hours_standardized         0
Caffeine_Intake_mg_standardized           0
Bedtime_Consistency_standardized          0
Light_Exposure_hours_standardized         0
Caffeine_Squared_Smoothed_standardized    0
dtype: int64
Heart_Rate_Variability                    0
Movement_During_Sleep                     0
Sleep_Duration_Hours                      0
Sleep_Quality_Score                       0
Caffeine_Intake_mg                        0
Bedtime_Consistency                       0
Light_Exposure_hours                      0
Caffeine_Squared_Smoothed                 0
Heart_Rate_Variability_normalized         0
Movement_During_Sleep_normalized          0
Sleep_Duration_Hours_normalized           0
Caffeine_Intake_mg_normalized             0
Bedtime_Consistency_normalized            0
Light_Exposure_hours_normalized           0
Caffeine_Squared_Smoothed_normalized      0
Heart_Rate_Variability_standardized       0
```

```
Movement_During_Sleep_standardized        0
Sleep_Duration_Hours_standardized         0
Caffeine_Intake_mg_standardized           0
Bedtime_Consistency_standardized          0
Light_Exposure_hours_standardized         0
Caffeine_Squared_Smoothed_standardized    0
dtype: int64
Originale Datengröße: (1000, 22)
Bereinigte Datengröße: (1000, 22)
```

```
df_imputed = df_imputed[['Caffeine_Intake_mg',
'Movement_During_Sleep', 'Sleep_Duration_Hours',
                        'Light_Exposure_hours', 'Bedtime_Consistency',
'Heart_Rate_Variability',
                        'Sleep_Quality_Score']]

correlation = df_imputed.corr()
print(correlation)

import seaborn as sns
import matplotlib.pyplot as plt

plt.figure(figsize=(10, 8))
sns.heatmap(correlation, annot=True, cmap='coolwarm', vmin=-1, vmax=1)
plt.title('Correlation Heatmap of Selected Features')
plt.show()
```

```
                        Caffeine_Intake_mg  Movement_During_Sleep  \
Caffeine_Intake_mg                1.000000               0.002097
Movement_During_Sleep             0.002097               1.000000
Sleep_Duration_Hours              0.033951               0.021586
Light_Exposure_hours              0.011756               0.001739
Bedtime_Consistency               0.056263              -0.039408
Heart_Rate_Variability           -0.008619               0.022129
Sleep_Quality_Score              -0.721968              -0.064108

                        Sleep_Duration_Hours  Light_Exposure_hours  \
Caffeine_Intake_mg                  0.033951              0.011756
Movement_During_Sleep               0.021586              0.001739
Sleep_Duration_Hours                1.000000              0.004894
Light_Exposure_hours                0.004894              1.000000
Bedtime_Consistency                -0.002974              0.026786
Heart_Rate_Variability             -0.013321             -0.016585
Sleep_Quality_Score                 0.042104             -0.007448

                        Bedtime_Consistency  Heart_Rate_Variability  \
Caffeine_Intake_mg                 0.056263               -0.008619
Movement_During_Sleep             -0.039408                0.022129
Sleep_Duration_Hours              -0.002974               -0.013321
Light_Exposure_hours               0.026786               -0.016585
```

```
Bedtime_Consistency              1.000000                 0.048199
Heart_Rate_Variability           0.048199                 1.000000
Sleep_Quality_Score             -0.076633                 0.026911

                        Sleep_Quality_Score
Caffeine_Intake_mg                -0.721968
Movement_During_Sleep             -0.064108
Sleep_Duration_Hours               0.042104
Light_Exposure_hours              -0.007448
Bedtime_Consistency               -0.076633
Heart_Rate_Variability             0.026911
Sleep_Quality_Score                1.000000
```



Caffeine_Intake_mg:

Hat die stärkste Korrelation mit Sleep_Quality_Score (-0.722) Dies ist eine starke negative Korrelation, was bedeutet, dass höhere Koffeinaufnahme stark mit niedrigerer Schlafqualität verbunden ist Movement_During_Sleep:

Zeigt eine schwache negative Korrelation mit Sleep_Quality_Score (-0.064) Mehr Bewegung während des Schlafes ist leicht mit niedrigerer Schlafqualität verbunden Sleep_Duration_Hours:

Hat eine sehr schwache positive Korrelation mit Sleep_Quality_Score (0.042) Längerer Schlaf ist minimal mit besserer Schlafqualität verbunden Light_Exposure_hours:

Zeigt eine vernachlässigbare negative Korrelation mit Sleep_Quality_Score (-0.007) Lichtexposition scheint kaum Einfluss auf die Schlafqualität zu haben Bedtime_Consistency:

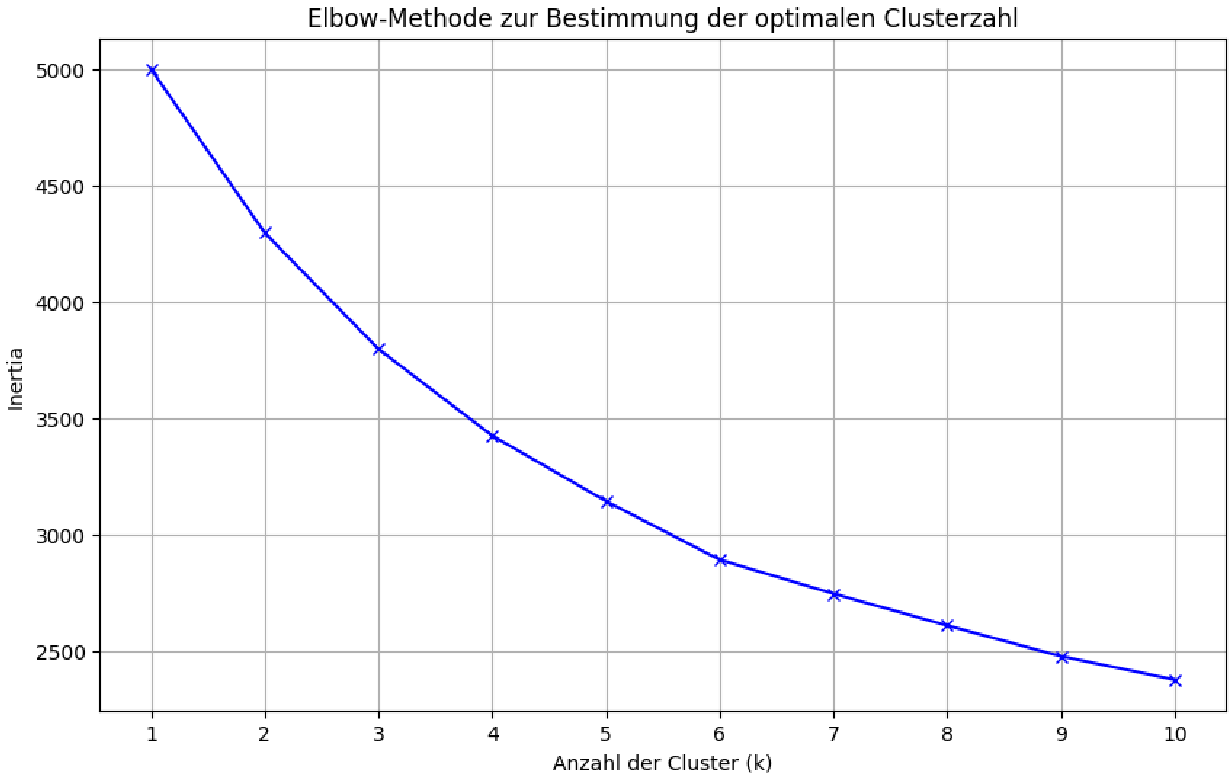
Hat eine schwache negative Korrelation mit Sleep_Quality_Score (-0.077) Überraschenderweise scheint konsistentere Schlafenszeit leicht mit niedrigerer Schlafqualität verbunden zu sein Heart_Rate_Variability:

Zeigt eine sehr schwache positive Korrelation mit Sleep_Quality_Score (0.027) Höhere Herzfrequenzvariabilität ist minimal mit besserer Schlafqualität verbunden Wichtige Beobachtungen:

Koffeinaufnahme ist bei weitem der stärkste Prädiktor für die Schlafqualität. Die meisten anderen Variablen zeigen nur schwache oder vernachlässigbare Korrelationen mit der Schlafqualität. Es gibt keine starken Korrelationen zwischen den unabhängigen Variablen, was gut für die Modellierung ist (keine Multikollinearität).

Clusteranalyse

```python
# Entfernen von Light_Exposure_hours
df_imputed = df_imputed.drop(['Light_Exposure_hours',
'Sleep_Quality_Score'], axis=1)

# Standardisierung der Daten für das Clustering
from sklearn.preprocessing import StandardScaler

scaler = StandardScaler()
df_scaled = pd.DataFrame(scaler.fit_transform(df_cluster),
columns=df_cluster.columns)

from sklearn.cluster import KMeans
import matplotlib.pyplot as plt
import numpy as np

inertias = []
k_range = range(1, 11)  # Betrachten Sie Cluster von 1 bis 10

for k in k_range:
    kmeans = KMeans(n_clusters=k, random_state=42, n_init=10)
    kmeans.fit(df_scaled)
    inertias.append(kmeans.inertia_)

plt.figure(figsize=(10, 6))
plt.plot(k_range, inertias, 'bx-')
plt.xlabel('Anzahl der Cluster (k)')
plt.ylabel('Inertia')
plt.title('Elbow-Methode zur Bestimmung der optimalen Clusterzahl')
plt.xticks(k_range)
plt.grid(True)
plt.show()
```



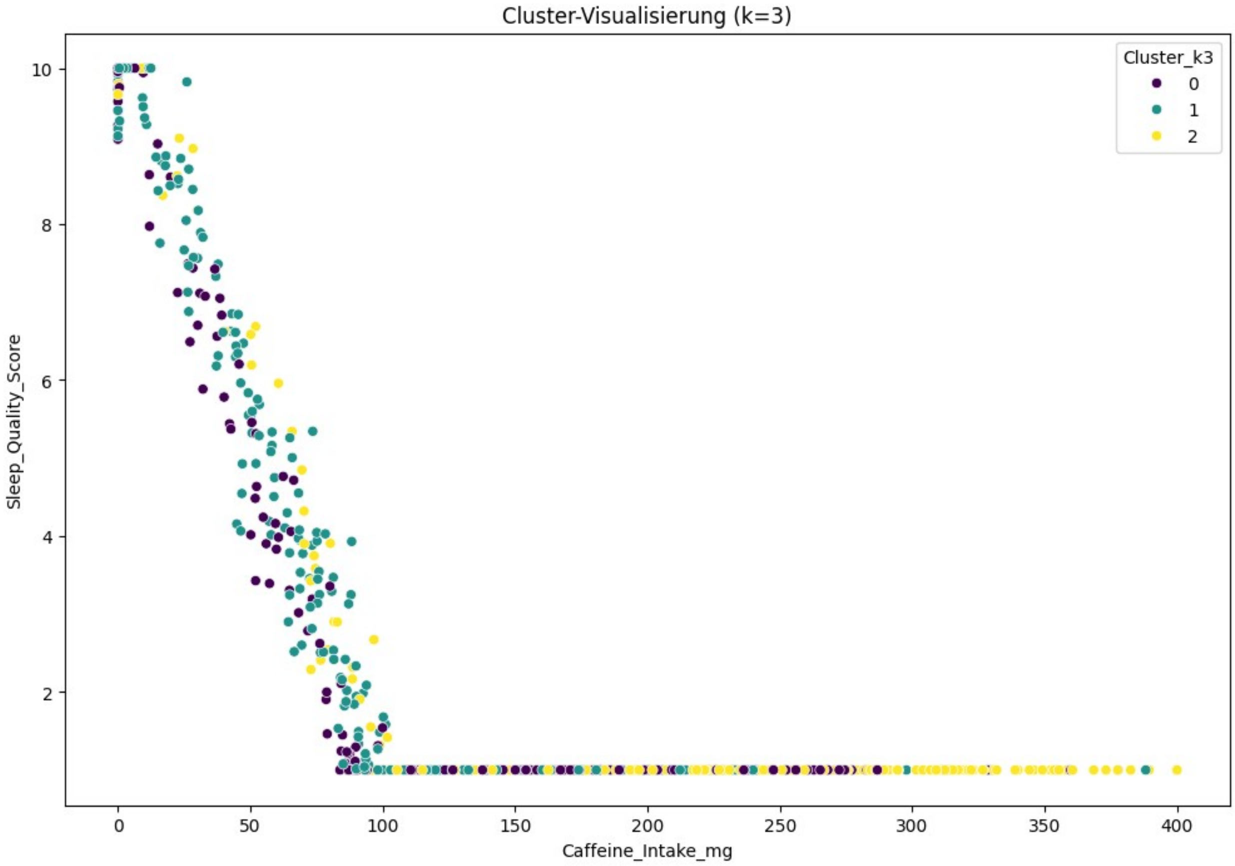
Bei k=2 gibt es einen starken Abfall, aber das wären sehr wenige Cluster.

Bei k=3 oder k=4 sehen wir weitere deutliche Abnahmen der Inertia.

Ab k=5 beginnt die Kurve, sich abzuflachen, wobei die Abnahme der Inertia weniger steil wird.

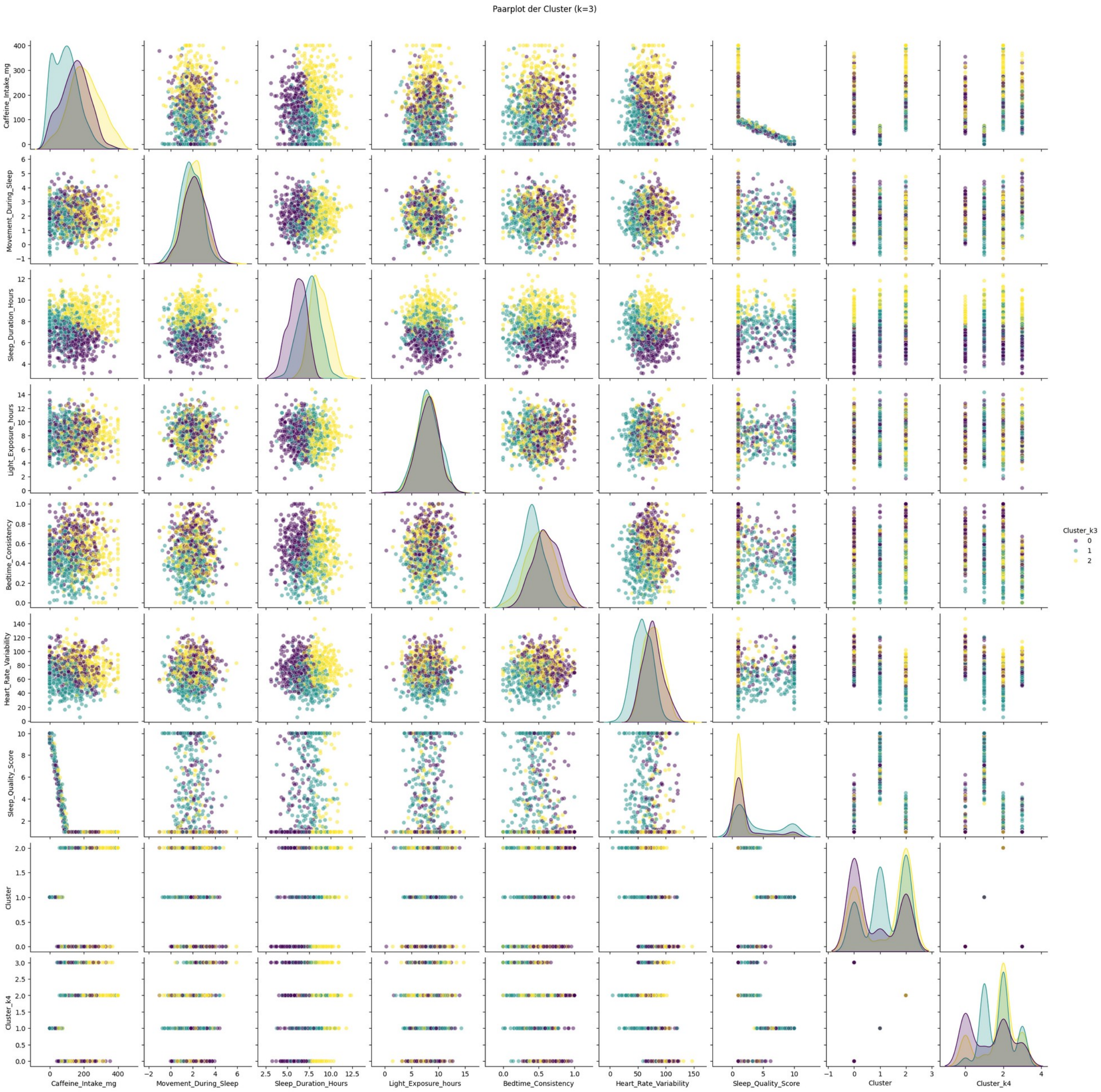
```python
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.cluster import KMeans
from sklearn.preprocessing import StandardScaler

# Standardisierung der Daten
scaler = StandardScaler()
df_imputed = pd.DataFrame(scaler.fit_transform(df_selected),
columns=df_selected.columns)
```

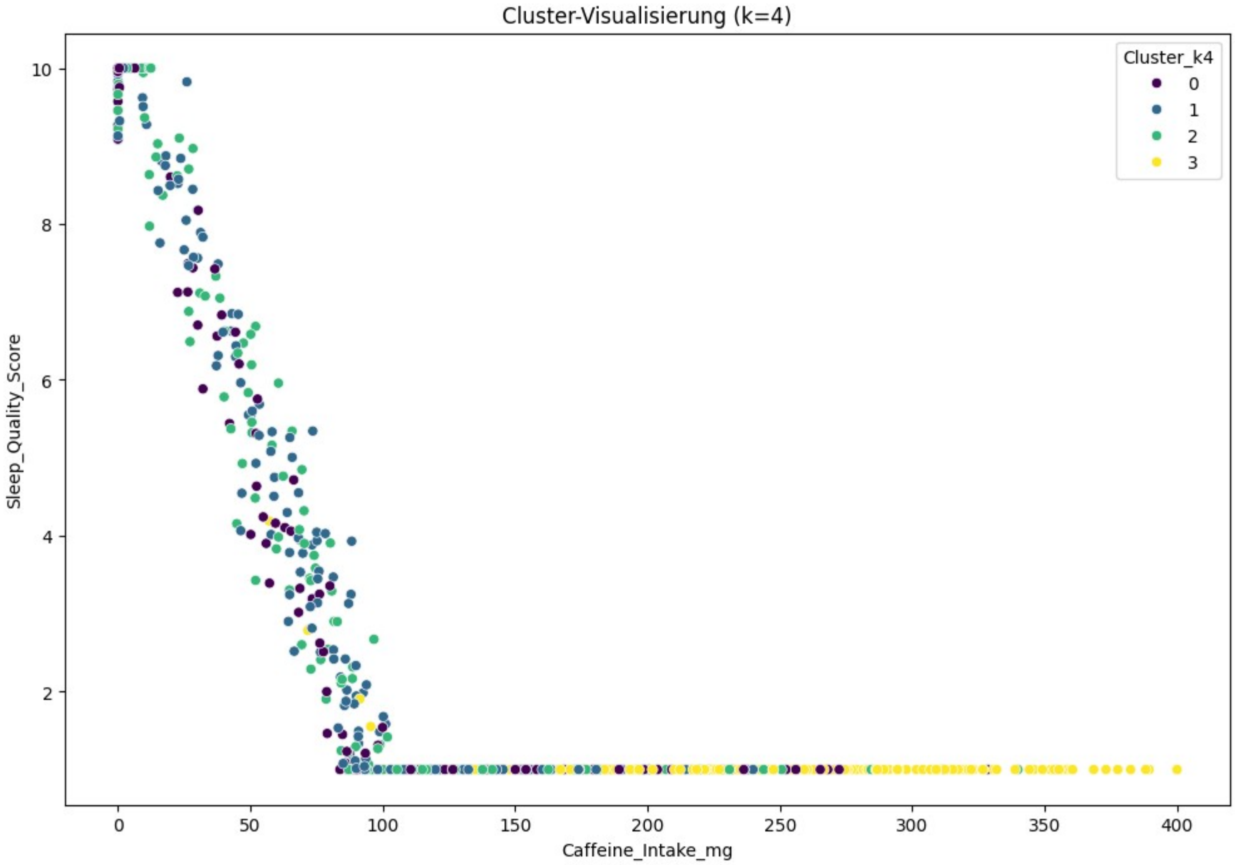
```
# K-Means Clustering für k=3 und k=4
for k in [3, 4]:
    kmeans = KMeans(n_clusters=k, random_state=42)
    cluster_labels = kmeans.fit_predict(df_scaled)

    # Fügen Sie die Cluster-Labels zum ursprünglichen DataFrame hinzu
    df_selected[f'Cluster_k{k}'] = cluster_labels

    # Visualisierung der Cluster
    plt.figure(figsize=(12, 8))
    sns.scatterplot(data=df_selected, x='Caffeine_Intake_mg',
y='Sleep_Quality_Score', hue=f'Cluster_k{k}', palette='viridis')
    plt.title(f'Cluster-Visualisierung (k={k})')
    plt.show()

    # Zusammenfassung der Cluster-Eigenschaften
    cluster_summary = df_selected.groupby(f'Cluster_k{k}').mean()
    print(f"Cluster-Zusammenfassung für k={k}:")
    print(cluster_summary)
    print("\n")

    # Paarplot für k=3 und k=4
    plt.figure(figsize=(20, 20))
    sns.pairplot(df_selected, hue=f'Cluster_k{k}', palette='viridis',
diag_kind='kde', plot_kws={'alpha': 0.5})
    plt.suptitle(f'Paarplot der Cluster (k={k})', y=1.02)
    plt.show()
```



```
Cluster-Zusammenfassung für k=3:
            Caffeine_Intake_mg  Movement_During_Sleep
Sleep_Duration_Hours  \
Cluster_k3

0                   148.132580               2.176215
6.085689
1                    93.596065               1.804834
7.492476
2                   205.329033               2.054517
8.758117

            Light_Exposure_hours  Bedtime_Consistency
Heart_Rate_Variability  \
Cluster_k3

0                       8.062947             0.607398
76.783770
1                       8.038578             0.392282
58.063065
2                       8.009936             0.523516
77.190926
```

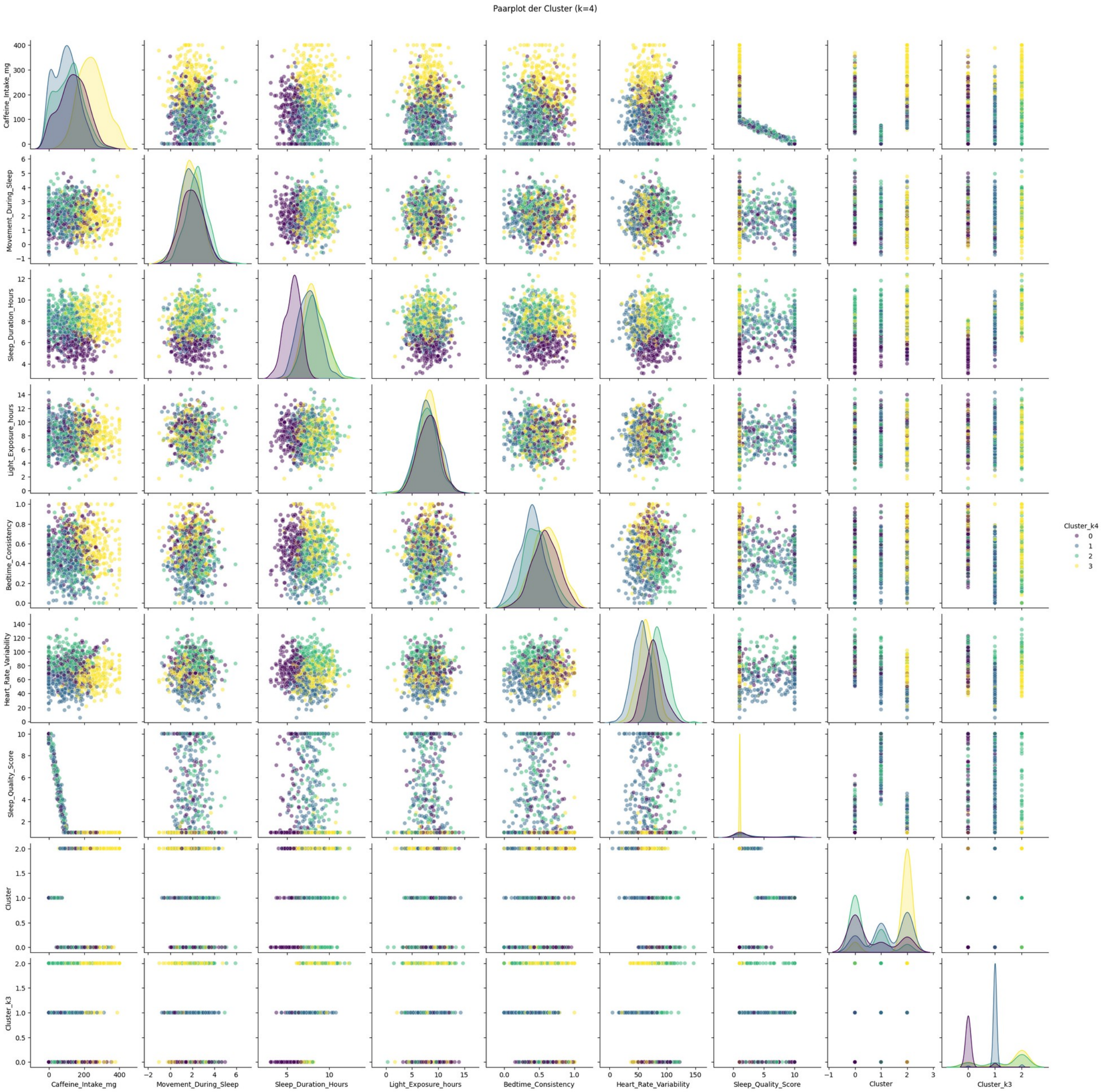
```
             Sleep_Quality_Score   Cluster  Cluster_k4
Cluster_k3
0                       2.182021  0.794304    1.278481
1                       3.989172  1.203438    1.736390
2                       1.525988  1.214925    1.779104



<Figure size 2000x2000 with 0 Axes>
```





```
Cluster-Zusammenfassung für k=4:
            Caffeine_Intake_mg  Movement_During_Sleep
Sleep_Duration_Hours  \
Cluster_k4

0                   135.801116               1.971834
5.656734
1                    94.585735               1.860084
7.538192
2                   113.549833               2.387798
8.337059
3                   244.324851               1.835376
8.156727

            Light_Exposure_hours  Bedtime_Consistency
Heart_Rate_Variability  \
Cluster_k4

0                       8.170749             0.585865
76.501104
1                       8.056437             0.381194
53.878633
2                       7.767196             0.458553
```

```
88.982215
3                       8.147540             0.600494
64.998892

            Sleep_Quality_Score   Cluster  Cluster_k3
Cluster_k4
0                      2.400957  0.648889    0.080000
1                      3.731820  1.272388    1.011194
2                      3.237232  0.443983    1.381743
3                      1.024173  1.819549    1.492481



<Figure size 2000x2000 with 0 Axes>
```



Die 3-Cluster-Lösung zeigt eine klare Trennung basierend auf Koffeinaufnahme und Schlafqualität. Die 4-Cluster-Lösung bietet eine feinere Unterteilung, insbesondere bei den Gruppen mit höherer Koffeinaufnahme. Interpretation der 3-Cluster-Lösung:

Cluster 0: Mittlere Koffeinaufnahme, kürzeste Schlafdauer, niedrige Schlafqualität Cluster 1: Niedrigste Koffeinaufnahme, mittlere Schlafdauer, höchste Schlafqualität Cluster 2: Höchste Koffeinaufnahme, längste Schlafdauer, niedrigste Schlafqualität Interpretation der 4-Cluster-Lösung:

Cluster 0: Mittlere Koffeinaufnahme, kürzeste Schlafdauer, mittlere Schlafqualität Cluster 1: Niedrigste Koffeinaufnahme, mittlere Schlafdauer, hohe Schlafqualität Cluster 2: Mittlere Koffeinaufnahme, lange Schlafdauer, mittlere Schlafqualität Cluster 3: Höchste Koffeinaufnahme, lange Schlafdauer, niedrigste Schlafqualität Beobachtungen:

Koffeinaufnahme scheint nicht linear mit der Schlafqualität oder -dauer zusammenzuhängen. Die Gruppe mit der höchsten Koffeinaufnahme hat interessanterweise eine lange Schlafdauer, aber die niedrigste Schlafqualität. Die Gruppe mit der niedrigsten Koffeinaufnahme hat die beste Schlafqualität, aber nicht die längste Schlafdauer. Empfehlung:

Die 4-Cluster-Lösung bietet eine nuanciertere Sicht auf die Daten und könnte für weitere Analysen vorteilhaft sein. Sie zeigt deutlicher die Komplexität der Beziehungen zwischen Koffeinaufnahme, Schlafdauer und Schlafqualität.

```
df_imputed['Caffeine_Sleep_Interaction'] =
df_imputed['Caffeine_Intake_mg'] * df_imputed['Sleep_Duration_Hours']

df_imputed.head()

df_imputed.info()

df_imputed.describe()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 11 columns):
 #   Column                      Non-Null Count  Dtype
---  ------                      --------------  -----
 0   Caffeine_Intake_mg          1000 non-null   float64
 1   Movement_During_Sleep       1000 non-null   float64
 2   Sleep_Duration_Hours        1000 non-null   float64
 3   Light_Exposure_hours        1000 non-null   float64
 4   Bedtime_Consistency         1000 non-null   float64
 5   Heart_Rate_Variability      1000 non-null   float64
 6   Sleep_Quality_Score         1000 non-null   float64
 7   Cluster                     1000 non-null   float64
 8   Cluster_k3                  1000 non-null   float64
 9   Cluster_k4                  1000 non-null   float64
 10  Caffeine_Sleep_Interaction  1000 non-null   float64
dtypes: float64(11)
memory usage: 86.1 KB

       Caffeine_Intake_mg  Movement_During_Sleep  Sleep_Duration_Hours
\
count        1.000000e+03           1.000000e+03          1.000000e+03

mean         8.348877e-17          -1.172396e-16         -2.806644e-16

std          1.000500e+00           1.000500e+00          1.000500e+00

min         -1.577492e+00          -3.077784e+00         -2.835258e+00

25%         -7.195789e-01          -6.651667e-01         -7.000663e-01
```

```
50%        -2.705605e-02          -6.190450e-03          1.841364e-02

75%         6.701571e-01           6.664355e-01          6.678863e-01

max         2.678519e+00           3.988355e+00          3.177238e+00


       Light_Exposure_hours  Bedtime_Consistency
Heart_Rate_Variability  \
count          1.000000e+03         1.000000e+03
1.000000e+03
mean          -2.469136e-16         1.429967e-16            -1.039169e-
16
std            1.000500e+00         1.000500e+00
1.000500e+00
min           -3.812377e+00        -2.471260e+00            -
3.331472e+00
25%           -6.479525e-01        -6.991636e-01            -6.814187e-
01
50%            7.735586e-04        -1.581227e-02             6.098290e-
03
75%            6.515780e-01         6.884037e-01             6.422755e-
01
max            3.321904e+00         2.429873e+00
3.916723e+00

       Sleep_Quality_Score       Cluster    Cluster_k3
Cluster_k4  \
count         1.000000e+03  1.000000e+03  1.000000e+03  1.000000e+03

mean         -5.329071e-17 -1.048051e-16 -1.048051e-16 -1.065814e-16

std           1.000500e+00  1.000500e+00  1.000500e+00  1.000500e+00

min          -5.349029e-01 -1.202302e+00 -1.202302e+00 -1.630004e+00

25%          -5.349029e-01 -1.202302e+00 -1.202302e+00 -6.150576e-01

50%          -5.349029e-01 -8.699399e-02 -8.699399e-02  3.998889e-01

75%          -1.852125e-02  1.028314e+00  1.028314e+00  3.998889e-01

max           2.487250e+00  1.028314e+00  1.028314e+00  1.414835e+00


       Caffeine_Sleep_Interaction
count                 1000.000000
mean                     0.033951
std                      0.988033
min                     -6.005490
```

```
25%                     -0.348343
50%                      0.006679
75%                      0.380347
max                      6.601293

# Specify the file path
file_path = '../data/imputed_dataset.csv'

# Save the DataFrame to a CSV file
df_imputed.to_csv(file_path, index=False)
```