In [4]:
```python
import pandas as pd
import numpy as np
from sklearn.preprocessing import LabelEncoder
from sklearn.model_selection import train_test_split, cross_validate, Stratifi
from sklearn.svm import SVC
from sklearn.metrics import confusion_matrix, accuracy_score, precision_score,
import matplotlib.pyplot as plt
```

In [5]:
```python
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

In [6]:
```python
file_path='/content/drive/MyDrive/MACHINE LEARNING/ObesityDataSet.csv'
df = pd.read_csv(file_path)
```

In [7]:
```python
X = df.drop('NObeyesdad', axis=1)
y = df['NObeyesdad']
```

In [8]:
```python
le_target = LabelEncoder()
y_encoded = le_target.fit_transform(y)
```

In [9]:
```python
X_encoded = X.copy()
for col in X_encoded.select_dtypes(include='object').columns:
    X_encoded[col] = LabelEncoder().fit_transform(X_encoded[col])
```

In [10]:
```python
X_train, X_test, y_train, y_test = train_test_split(
    X_encoded, y_encoded, test_size=0.3, stratify=y_encoded, random_state=42)
```

In [11]:
```python
kernels = {
    'rbf': {'C': 1.0, 'gamma': 'scale'},
    'linear': {'C': 1.0},
    'poly': {'degree': 3, 'C': 1.0, 'gamma': 'scale'},
    'sigmoid': {'C': 1.0, 'gamma': 'scale'}
}
```

In [21]:
```python
def train_evaluate_svm(kernel, params, X_train, X_test, y_train, y_test):
    print(f"\nTraining SVM with kernel = '{kernel}'")
    model = SVC(kernel=kernel, **params, random_state=42)
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)

    cm = confusion_matrix(y_test, y_pred)
    print("Confusion Matrix:\n", cm)

    acc = accuracy_score(y_test, y_pred)
    precision = precision_score(y_test, y_pred, average=None, zero_division=0)
    recall = recall_score(y_test, y_pred, average=None, zero_division=0)
    f1 = f1_score(y_test, y_pred, average=None, zero_division=0)

    print(f"Accuracy: {acc:.4f}")
    for i, label in enumerate(le_target.classes_):
        print(f"Class '{label}': Precision={precision[i]:.4f}, Recall={recall[

    return model, acc, precision.mean(), recall.mean(), f1.mean()

results = {}
```

In [22]:
```
for kernel, params in kernels.items():
    model, acc, prec, rec, f1 = train_evaluate_svm(kernel, params, X_train, X_
    results[kernel] = {'model': model, 'accuracy': acc, 'precision': prec, 're
```

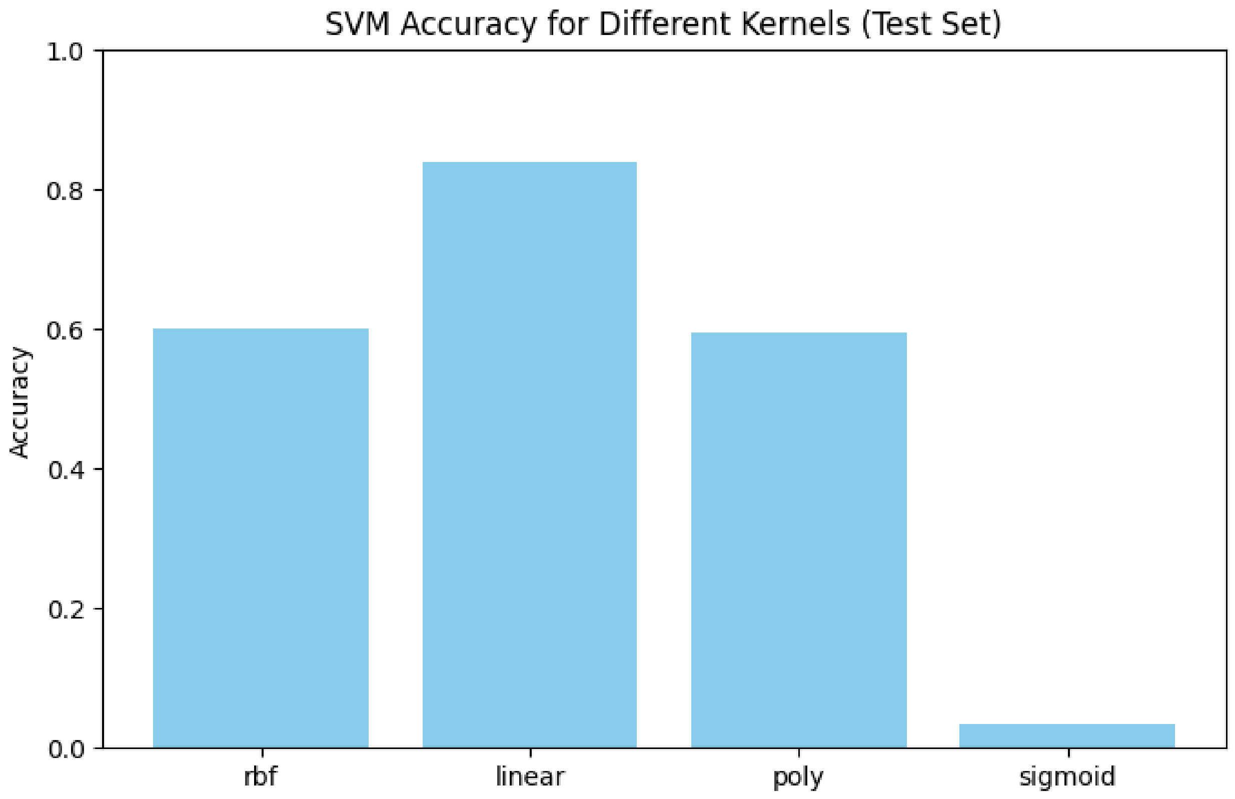
```
Training SVM with kernel = 'rbf'
Confusion Matrix:
 [[68 14  0  0  0  0  0]
 [24 41  0  0  0 19  2]
 [ 0  0 37  3 17  1 48]
 [ 0  0 11 41 37  0  0]
 [ 0  0  4  0 93  0  0]
 [ 2 16  4  0  0 54 11]
 [ 0  3 19  0  0 18 47]]
Accuracy: 0.6009
Class 'Insufficient_Weight': Precision=0.7234, Recall=0.8293, F1-score=0.7727
Class 'Normal_Weight': Precision=0.5541, Recall=0.4767, F1-score=0.5125
Class 'Obesity_Type_I': Precision=0.4933, Recall=0.3491, F1-score=0.4088
Class 'Obesity_Type_II': Precision=0.9318, Recall=0.4607, F1-score=0.6165
Class 'Obesity_Type_III': Precision=0.6327, Recall=0.9588, F1-score=0.7623
Class 'Overweight_Level_I': Precision=0.5870, Recall=0.6207, F1-score=0.6034
Class 'Overweight_Level_II': Precision=0.4352, Recall=0.5402, F1-score=0.4821

Training SVM with kernel = 'linear'
Confusion Matrix:
 [[76  6  0  0  0  0  0]
 [11 59  0  0  0 15  1]
 [ 0  0 92  5  0  2  7]
 [ 0  0  3 86  0  0  0]
 [ 0  0  0  1 96  0  0]
 [ 0 12  1  0  0 67  7]
 [ 0  1 12  0  0 17 57]]
Accuracy: 0.8407
Class 'Insufficient_Weight': Precision=0.8736, Recall=0.9268, F1-score=0.8994
Class 'Normal_Weight': Precision=0.7564, Recall=0.6860, F1-score=0.7195
Class 'Obesity_Type_I': Precision=0.8519, Recall=0.8679, F1-score=0.8598
Class 'Obesity_Type_II': Precision=0.9348, Recall=0.9663, F1-score=0.9503
Class 'Obesity_Type_III': Precision=1.0000, Recall=0.9897, F1-score=0.9948
Class 'Overweight_Level_I': Precision=0.6634, Recall=0.7701, F1-score=0.7128
Class 'Overweight_Level_II': Precision=0.7917, Recall=0.6552, F1-score=0.7170

Training SVM with kernel = 'poly'
Confusion Matrix:
 [[74  8  0  0  0  0  0]
 [26 46  0  0  0 12  2]
 [ 0  0 44  3  5  3 51]
 [ 0  0 12 42 35  0  0]
 [ 0  0  4  0 93  0  0]
 [ 3 29  1  0  0 42 12]
 [ 0  5 17  0  0 28 37]]
Accuracy: 0.5962
Class 'Insufficient_Weight': Precision=0.7184, Recall=0.9024, F1-score=0.8000
Class 'Normal_Weight': Precision=0.5227, Recall=0.5349, F1-score=0.5287
Class 'Obesity_Type_I': Precision=0.5641, Recall=0.4151, F1-score=0.4783
Class 'Obesity_Type_II': Precision=0.9333, Recall=0.4719, F1-score=0.6269
Class 'Obesity_Type_III': Precision=0.6992, Recall=0.9588, F1-score=0.8087
Class 'Overweight_Level_I': Precision=0.4941, Recall=0.4828, F1-score=0.4884
Class 'Overweight_Level_II': Precision=0.3627, Recall=0.4253, F1-score=0.3915
```

```
Training SVM with kernel = 'sigmoid'
Confusion Matrix:
 [[ 2  0  0  0 80  0  0]
 [ 0  0  0  0 86  0  0]
 [ 0  4  0  0 99  3  0]
 [ 0 73  0  0 14  2  0]
 [ 2 63  0  0 20 12  0]
 [ 0  0  0  0 87  0  0]
 [ 0  0  0  0 87  0  0]]
Accuracy: 0.0347
Class 'Insufficient_Weight': Precision=0.5000, Recall=0.0244, F1-score=0.0465
Class 'Normal_Weight': Precision=0.0000, Recall=0.0000, F1-score=0.0000
Class 'Obesity_Type_I': Precision=0.0000, Recall=0.0000, F1-score=0.0000
Class 'Obesity_Type_II': Precision=0.0000, Recall=0.0000, F1-score=0.0000
Class 'Obesity_Type_III': Precision=0.0423, Recall=0.2062, F1-score=0.0702
Class 'Overweight_Level_I': Precision=0.0000, Recall=0.0000, F1-score=0.0000
Class 'Overweight_Level_II': Precision=0.0000, Recall=0.0000, F1-score=0.0000
```

In [23]:
```
plt.figure(figsize=(8, 5))
plt.bar(results.keys(), [v['accuracy'] for v in results.values()], color='skyb
plt.ylabel('Accuracy')
plt.title('SVM Accuracy for Different Kernels (Test Set)')
plt.ylim(0, 1)
plt.show()
```



In [24]:
```
cv_results = {'kernel': [], 'accuracy': [], 'precision': [], 'recall': [], 'f1
skf = StratifiedKFold(n_splits=5, shuffle=True, random_state=42)
```

In [41]:
```
cv_results = {'kernel': [], 'accuracy': [], 'precision': [], 'recall': [], 'f1
```

```python
for kernel, params in kernels.items():
    svm = SVC(kernel=kernel, **params, random_state=42)
    scoring = ['accuracy', 'precision_macro', 'recall_macro', 'f1_macro']
    scores = cross_validate(svm, X_encoded, y_encoded, cv=skf, scoring=scoring

    cv_results['kernel'].append(kernel)
    cv_results['accuracy'].append(np.mean(scores['test_accuracy']))
    cv_results['precision'].append(np.mean(scores['test_precision_macro']))
    cv_results['recall'].append(np.mean(scores['test_recall_macro']))
    cv_results['f1'].append(np.mean(scores['test_f1_macro']))
```

```
/usr/local/lib/python3.12/dist-packages/sklearn/metrics/_classification.py:156
5: UndefinedMetricWarning: Precision is ill-defined and being set to 0.0 in lab
els with no predicted samples. Use `zero_division` parameter to control this be
havior.
  _warn_prf(average, modifier, f"{metric.capitalize()} is", len(result))
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els with no predicted samples. Use `zero_division` parameter to control this be
havior.
  _warn_prf(average, modifier, f"{metric.capitalize()} is", len(result))
```

In [42]:
```python
cv_df = pd.DataFrame(cv_results)
```

In [34]:
```python
cv_df = pd.DataFrame(cv_results)
print("\nCross-validation results:")
print(cv_df)
```

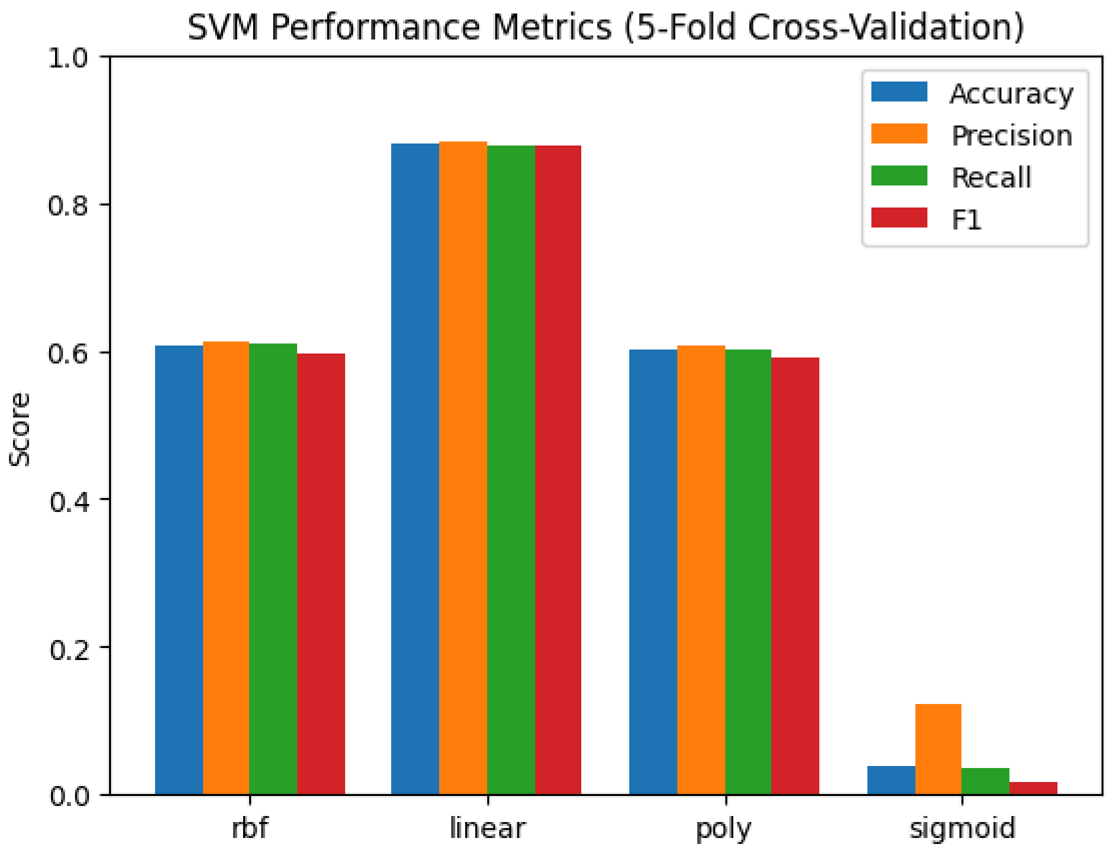
```
Cross-validation results:
    kernel  accuracy  precision    recall        f1
0  sigmoid  0.039321   0.121320  0.037008  0.016799
1      rbf  0.605868   0.611382  0.609128  0.595704
2   linear  0.881099   0.883006  0.878050  0.876302
3     poly  0.600660   0.606669  0.601402  0.589289
4  sigmoid  0.039321   0.121320  0.037008  0.016799
```

In [43]:
```python
plt.figure(figsize=(10, 6))
bar_width = 0.2
x = np.arange(len(kernels))
```

```
<Figure size 1000x600 with 0 Axes>
```

In [44]:
```
metrics = ['accuracy', 'precision', 'recall', 'f1']
for i, metric in enumerate(metrics):
    plt.bar(x + i * bar_width, cv_df[metric], width=bar_width, label=metric.ca

plt.xticks(x + bar_width * 1.5, cv_df['kernel'])
plt.ylim(0, 1)
plt.ylabel('Score')
plt.title('SVM Performance Metrics (5-Fold Cross-Validation)')
plt.legend()
plt.show()
```



In [45]:
```
rbf_model = results['rbf']['model']
print("\nFirst 5 Support Vectors (RBF kernel):")
print(rbf_model.support_vectors_[:5])
```

```
First 5 Support Vectors (RBF kernel):
[[ 0.   22.    1.67 50.    1.    1.    3.    3.    1.    0.    3.    0.
   1.    1.    3.    3.  ]
 [ 0.   19.    1.71 50.    0.    1.    1.    4.    1.    0.    1.    0.
   2.    1.    2.    3.  ]
 [ 1.   19.    1.7  50.    0.    1.    1.    4.    1.    0.    1.    0.
   2.    1.    2.    3.  ]
 [ 0.   20.    1.68 49.    0.    0.    3.    3.    2.    0.    2.    0.
   2.    1.    2.    3.  ]
 [ 1.   17.    1.71 52.    0.    1.    2.    2.    2.    0.    2.    0.
   0.    1.    2.    3.  ]]
```