Heart Disease Analysis

Heart disease or Cardiovascular disease (CVD) is a class of diseases that involve the heart or blood vessels. Cardiovascular diseases are the leading cause of death globally. This is true in all areas of the world except Africa. Together CVD resulted in 17.9 million deaths (32.1%) in 2015. Deaths, at a given age, from CVD are more common and have been increasing in much of the developing world, while rates have declined in most of the developed world since the 1970s.

So, in this kernel, I have conducted Exploratory Data Analysis or EDA of the heart disease dataset. Exploratory Data Analysis or EDA is a critical first step in analyzing a new dataset. The primary objective of EDA is to analyze the data for distribution, outliers and anomalies in the dataset. It enable us to direct specific testing of the hypothesis. It includes analysing the data to find the distribution of data, its main characteristics, identifying patterns and visualizations. It also provides tools for hypothesis generation by visualizing and understanding the data through graphical representation.

Import libraries

In [12]:
```
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)

# Input data files are available in the "../input/" directory.
# For example, running this (by clicking run or pressing Shift+Enter) will list all files under the input directory

import os
for dirname, _, filenames in os.walk('/kaggle/input'):
    for filename in filenames:
        print(os.path.join(dirname, filename))

# Any results you write to the current directory are saved as output.
```

In [13]:
```
import seaborn as sns
import matplotlib.pyplot as plt
import scipy.stats as st
%matplotlib inline
```

```
sns.set(style="whitegrid")
```

In [14]:
```
# ignore warnings

import warnings
warnings.filterwarnings('ignore')
```

I have imported the libraries. The next step is to import the datasets.

Import dataset

In [15]:
```
df = pd.read_csv('C:/Users/Rachana Jena/Downloads/9th- Seaborn, Eda practicle/9th- Seaborn, Eda practicle/EDA/heart.c
```

In [16]:
```
df
```

Out[16]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
0	63	1	3	145	233	1	0	150	0	2.3	0	0	1	1
1	37	1	2	130	250	0	1	187	0	3.5	0	0	2	1
2	41	0	1	130	204	0	0	172	0	1.4	2	0	2	1
3	56	1	1	120	236	0	1	178	0	0.8	2	0	2	1
4	57	0	0	120	354	0	1	163	1	0.6	2	0	2	1
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
298	57	0	0	140	241	0	1	123	1	0.2	1	0	3	0
299	45	1	3	110	264	0	1	132	0	1.2	1	0	3	0
300	68	1	0	144	193	1	1	141	0	3.4	1	2	3	0
301	57	1	0	130	131	0	1	115	1	1.2	1	1	3	0
302	57	0	1	130	236	0	0	174	0	0.0	1	1	2	0

303 rows × 14 columns

Exploratory Data Analysis

In [17]:
```
# print the shape
print('The shape of the dataset : ', df.shape)
```

```
The shape of the dataset :  (303, 14)
```

Now, we can see that the dataset contains 303 instances and 14 variables.

In [18]:
```
# Preview dataset
df.head()
```

Out[18]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
0	63	1	3	145	233	1	0	150	0	2.3	0	0	1	1
1	37	1	2	130	250	0	1	187	0	3.5	0	0	2	1
2	41	0	1	130	204	0	0	172	0	1.4	2	0	2	1
3	56	1	1	120	236	0	1	178	0	0.8	2	0	2	1
4	57	0	0	120	354	0	1	163	1	0.6	2	0	2	1

Summary of Dataset

In [19]:
```
# summary of dataset
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    int64  
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    int64  
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
 13  target    303 non-null    int64  
dtypes: float64(1), int64(13)
memory usage: 33.3 KB
```

In [21]:
```
df.dtypes
```

Out[21]:
```
age           int64
sex           int64
cp            int64
trestbps      int64
chol          int64
fbs           int64
restecg       int64
thalach       int64
exang         int64
oldpeak     float64
slope         int64
ca            int64
thal          int64
target        int64
dtype: object
```

In [22]:
```
# statistical properties of dataset
df.describe()
```

Out[22]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak
count	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000
mean	54.366337	0.683168	0.966997	131.623762	246.264026	0.148515	0.528053	149.646865	0.326733	1.039604
std	9.082101	0.466011	1.032052	17.538143	51.830751	0.356198	0.525860	22.905161	0.469794	1.161075
min	29.000000	0.000000	0.000000	94.000000	126.000000	0.000000	0.000000	71.000000	0.000000	0.000000
25%	47.500000	0.000000	0.000000	120.000000	211.000000	0.000000	0.000000	133.500000	0.000000	0.000000
50%	55.000000	1.000000	1.000000	130.000000	240.000000	0.000000	1.000000	153.000000	0.000000	0.800000
75%	61.000000	1.000000	2.000000	140.000000	274.500000	0.000000	1.000000	166.000000	1.000000	1.600000
max	77.000000	1.000000	3.000000	200.000000	564.000000	1.000000	2.000000	202.000000	1.000000	6.200000

In [23]:
```
df.columns
```

Out[23]:
```
Index(['age', 'sex', 'cp', 'trestbps', 'chol', 'fbs', 'restecg', 'thalach',
       'exang', 'oldpeak', 'slope', 'ca', 'thal', 'target'],
      dtype='object')
```

Univariate analysis

In [24]:
```
df['target'].nunique()
```

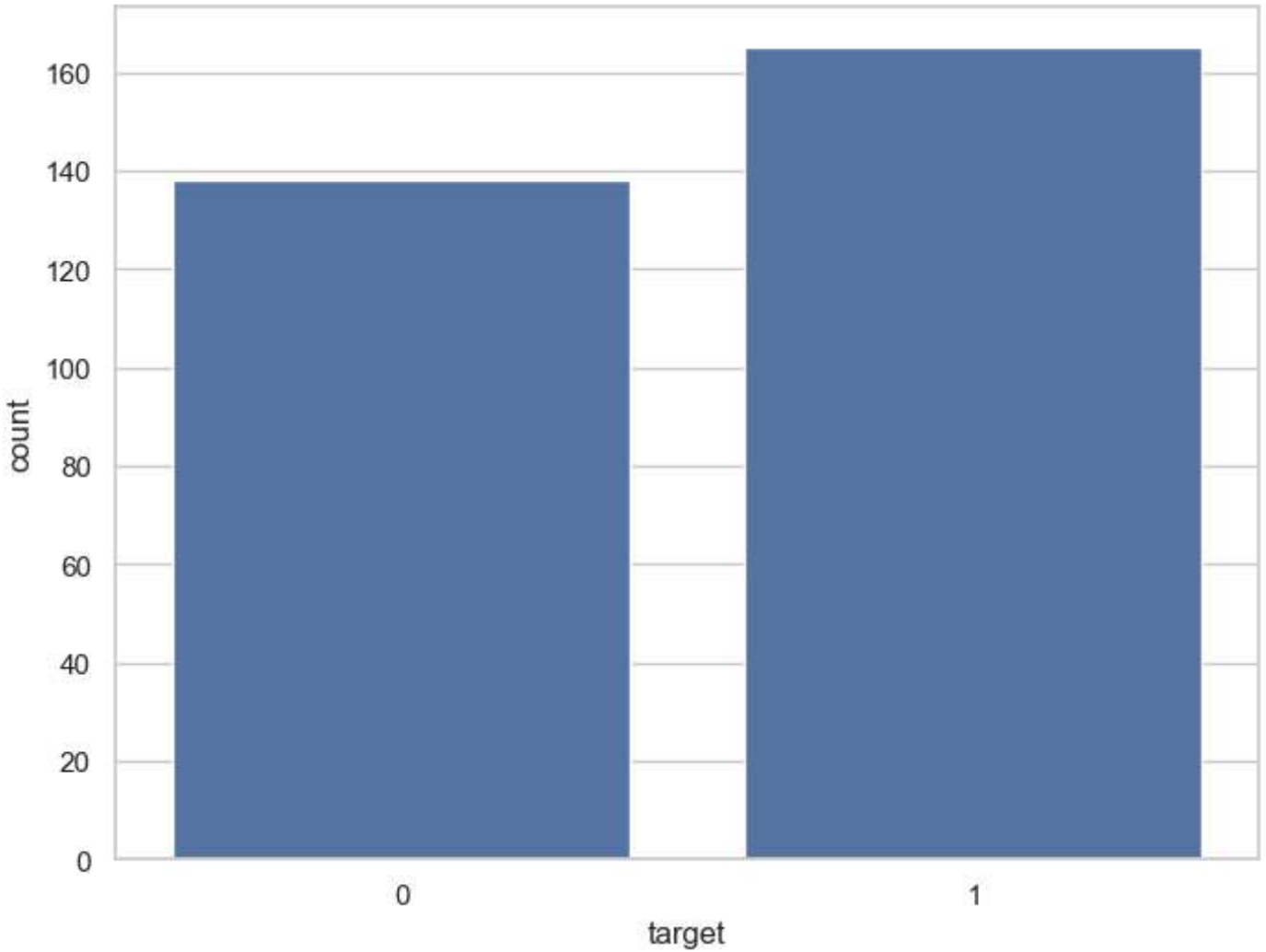
Out[24]:
```
2
```

In [25]:
```
df['target'].value_counts()
```

Out[25]:
```
target
1    165
0    138
Name: count, dtype: int64
```

Visualize frequency distribution of target variable

In [29]:
```
f, ax = plt.subplots(figsize=(8, 6))
ax = sns.countplot(x="target", data=df)
plt.show()
```



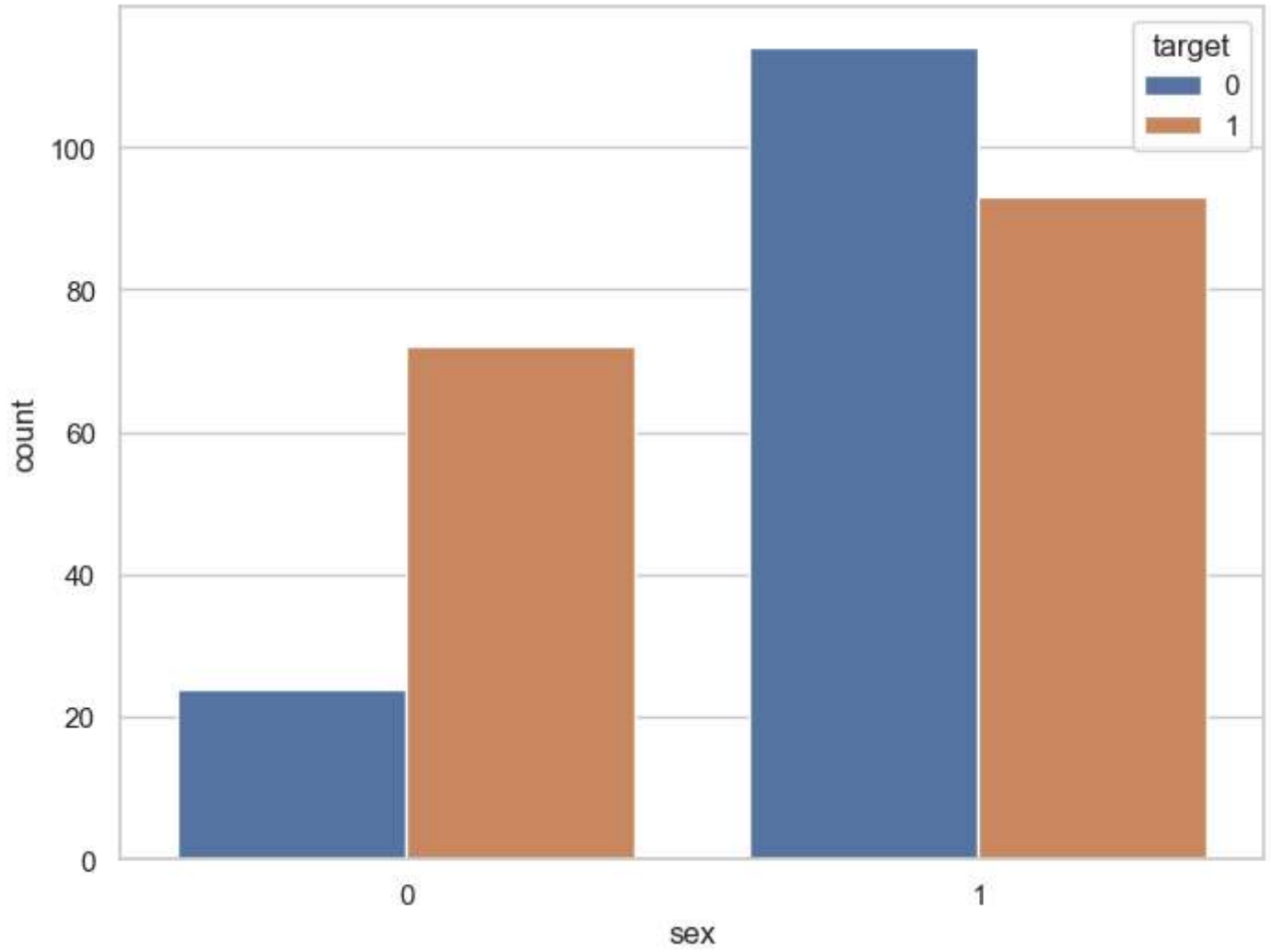
Frequency distribution of target variable wrt sex

In [27]:
```
df.groupby('sex')['target'].value_counts()
```

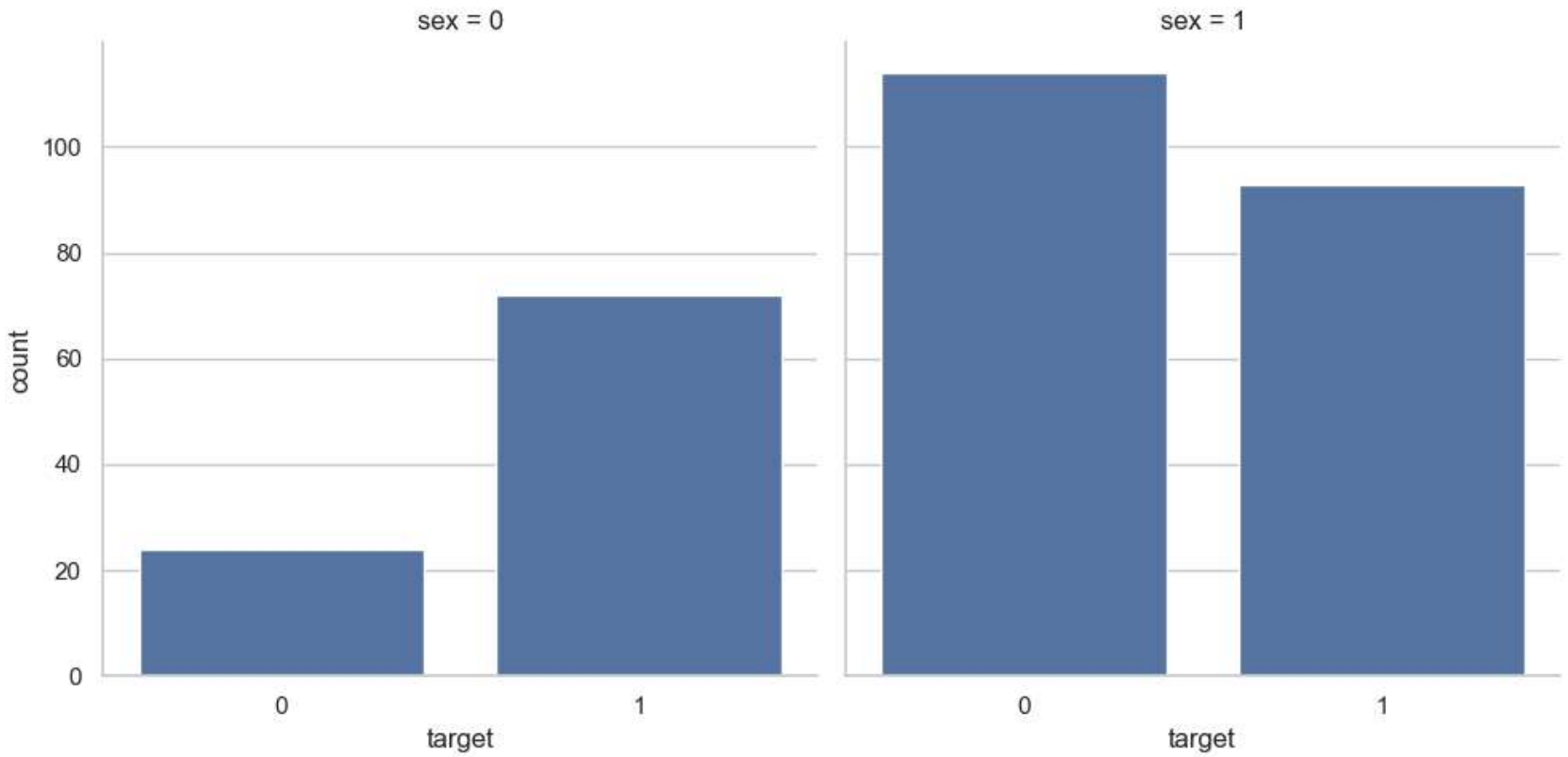
Out[27]:
```
sex  target
0    1          72
     0          24
1    0         114
     1          93
Name: count, dtype: int64
```

We can visualize the value counts of the `sex` variable wrt `target` as follows -

In [28]:
```
f, ax = plt.subplots(figsize=(8, 6))
ax = sns.countplot(x="sex", hue="target", data=df)
plt.show()
```

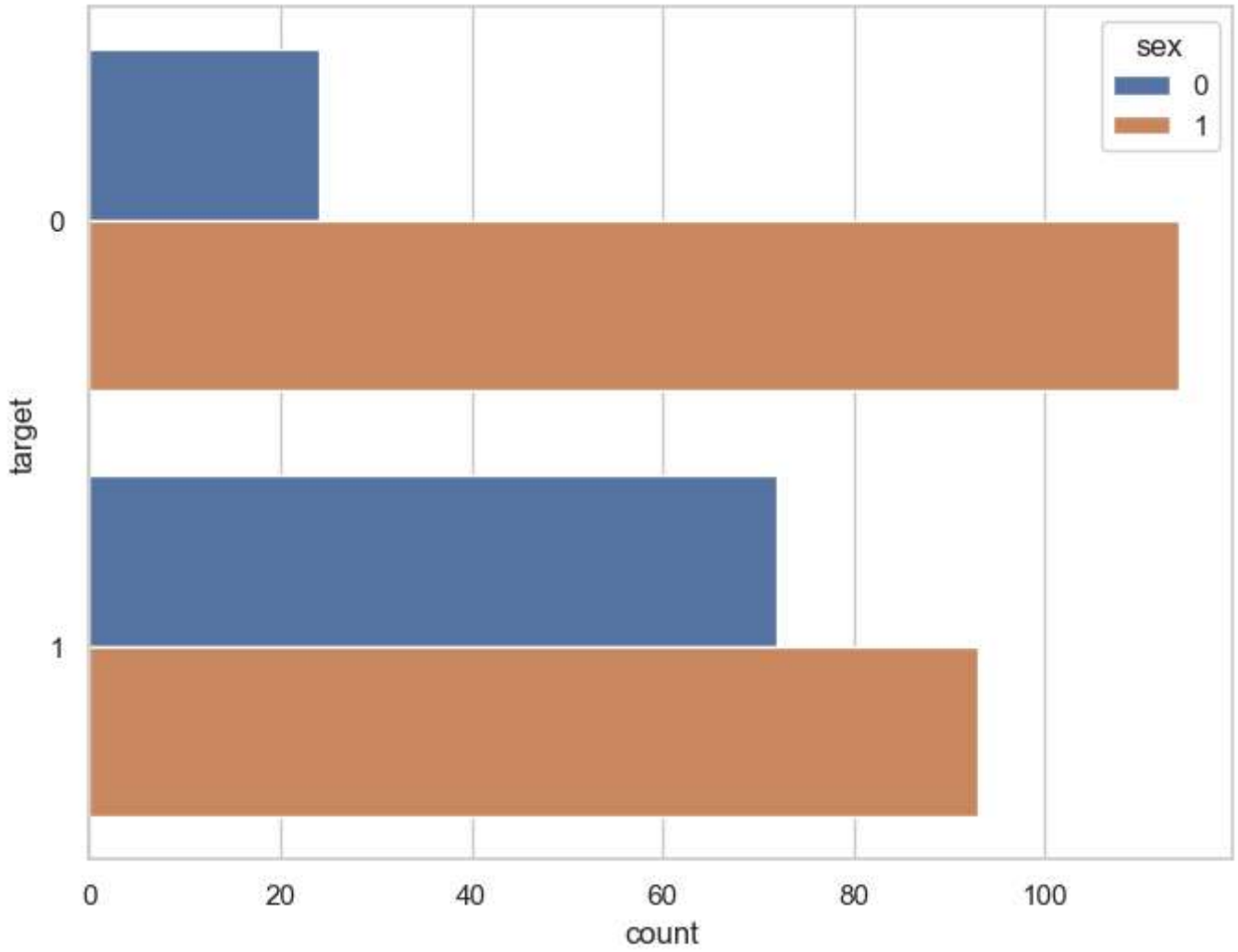


In [30]:
```
ax = sns.catplot(x="target", col="sex", data=df, kind="count", height=5, aspect=1)
```



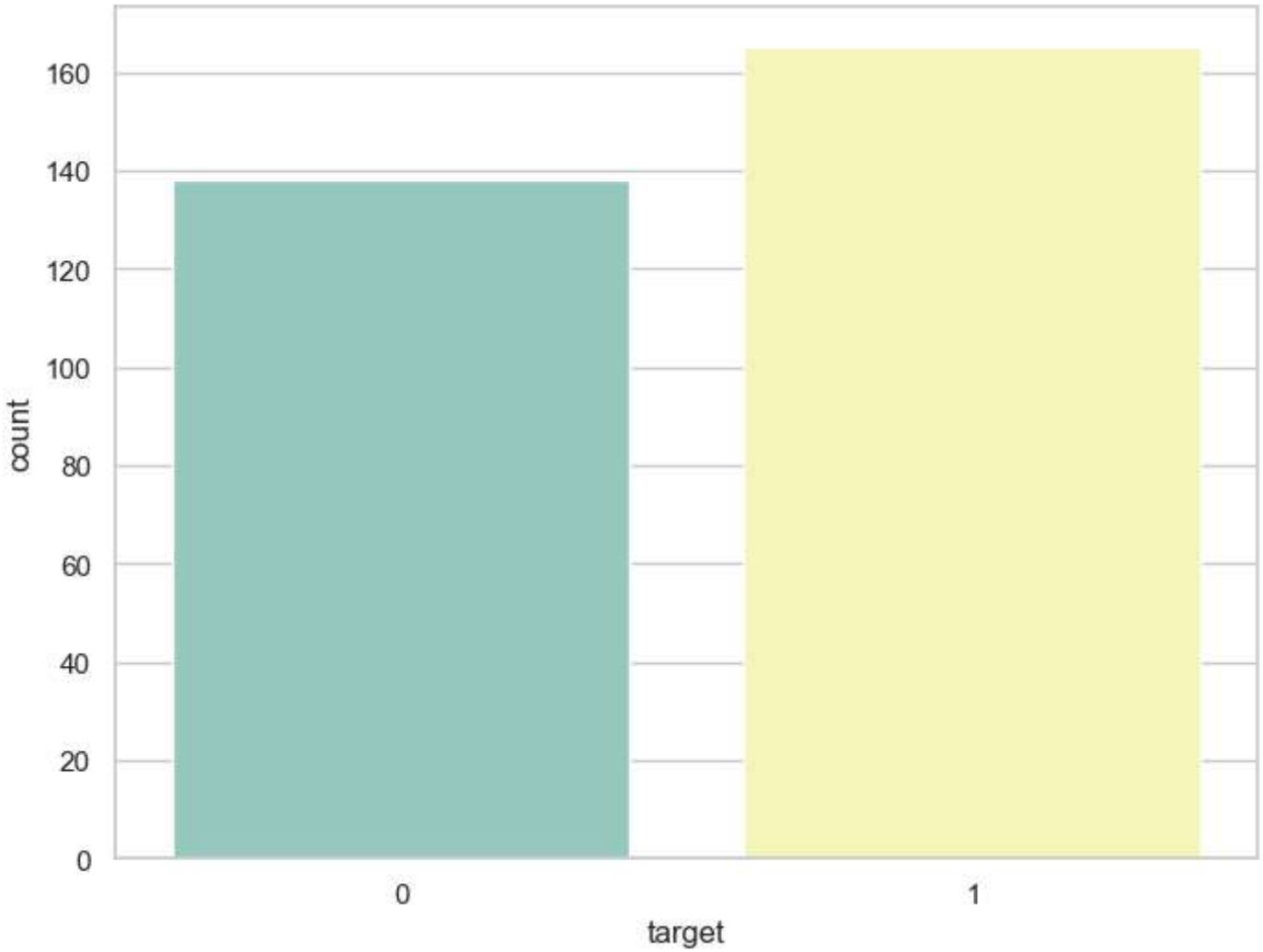
We can plot the bars horizontally as follows :

In [31]:
```
f, ax = plt.subplots(figsize=(8, 6))
ax = sns.countplot(y="target", hue="sex", data=df)
plt.show()
```

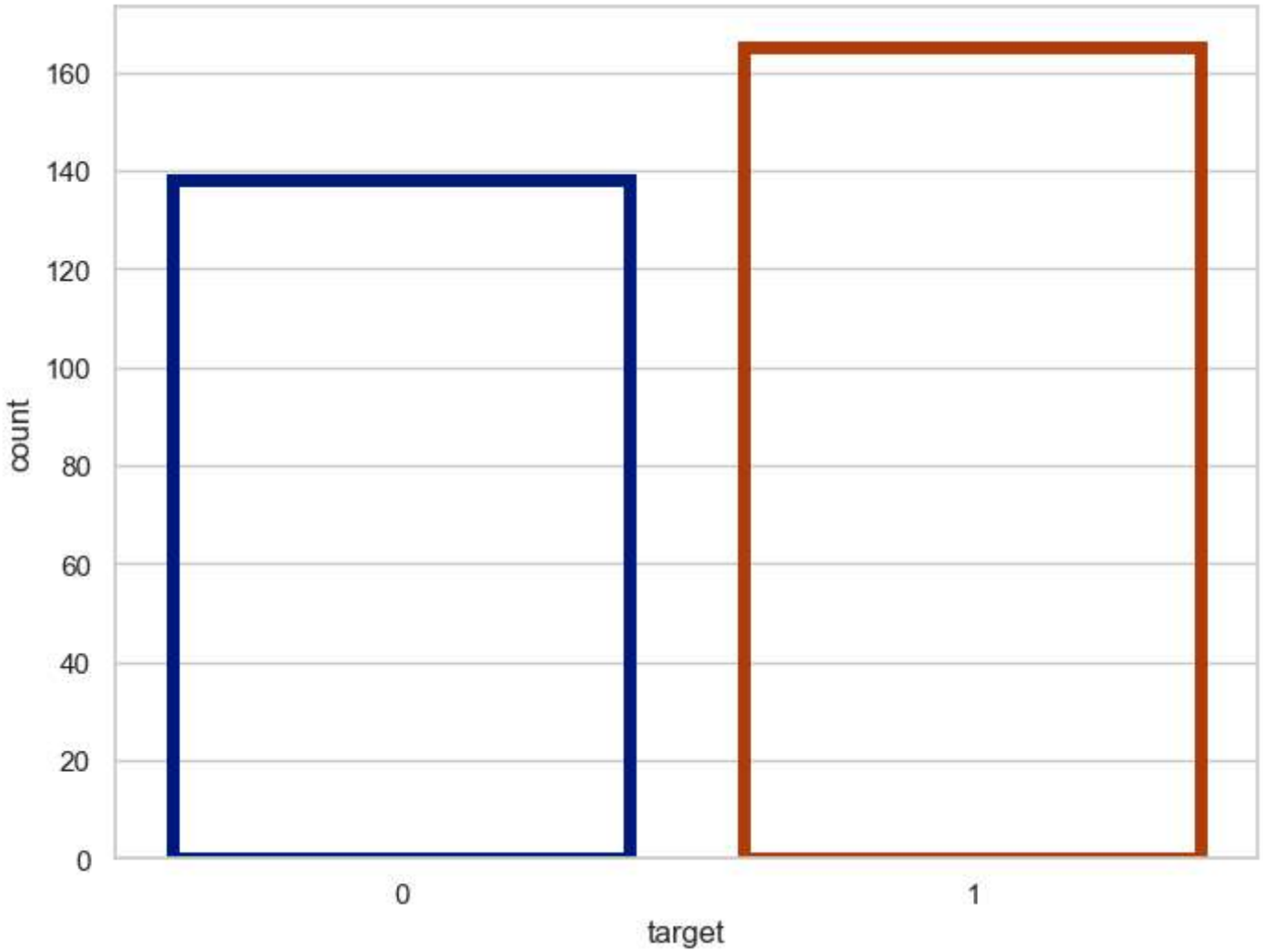


We can use a different color palette as follows :

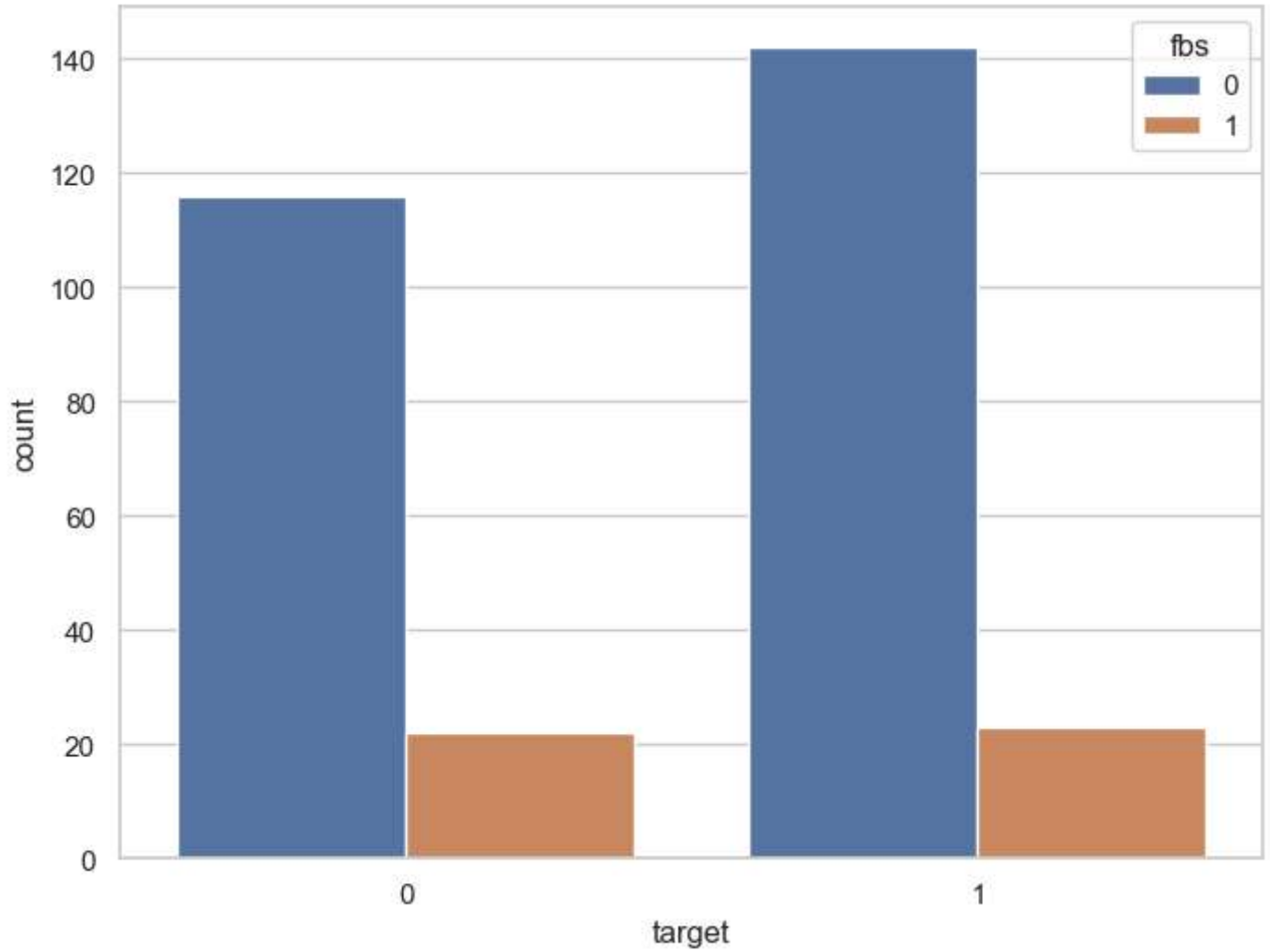
In [32]:
```
f, ax = plt.subplots(figsize=(8, 6))
ax = sns.countplot(x="target", data=df, palette="Set3")
plt.show()
```



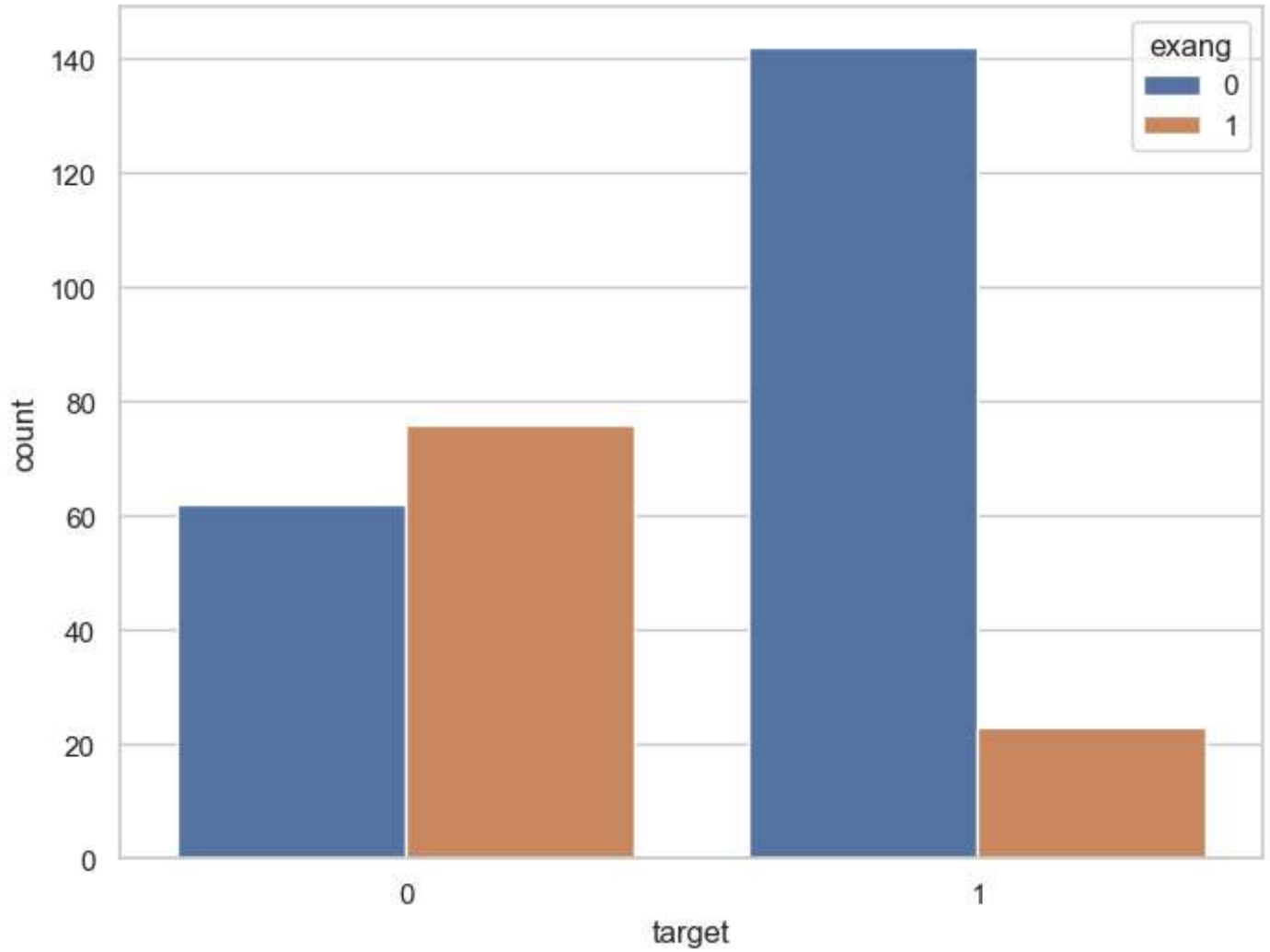
In [33]:
```
f, ax = plt.subplots(figsize=(8, 6))
ax = sns.countplot(x="target", data=df, facecolor=(0, 0, 0, 0), linewidth=5, edgecolor=sns.color_palette("dark", 3))
plt.show()
```



In [34]:
```
f, ax = plt.subplots(figsize=(8, 6))
ax = sns.countplot(x="target", hue="fbs", data=df)
plt.show()
```



In [35]:
```
f, ax = plt.subplots(figsize=(8, 6))
ax = sns.countplot(x="target", hue="exang", data=df)
plt.show()
```



Bivariate Analysis

In [36]:
```
correlation = df.corr()
```

In [37]:
```
correlation['target'].sort_values(ascending=False)
```

Out[37]:
```
target      1.000000
cp          0.433798
thalach     0.421741
slope       0.345877
restecg     0.137230
fbs        -0.028046
chol       -0.085239
trestbps   -0.144931
age        -0.225439
sex        -0.280937
thal       -0.344029
ca         -0.391724
oldpeak    -0.430696
exang      -0.436757
Name: target, dtype: float64
```

Analysis of target and cp variable

In [38]:
```
df['cp'].nunique()
```

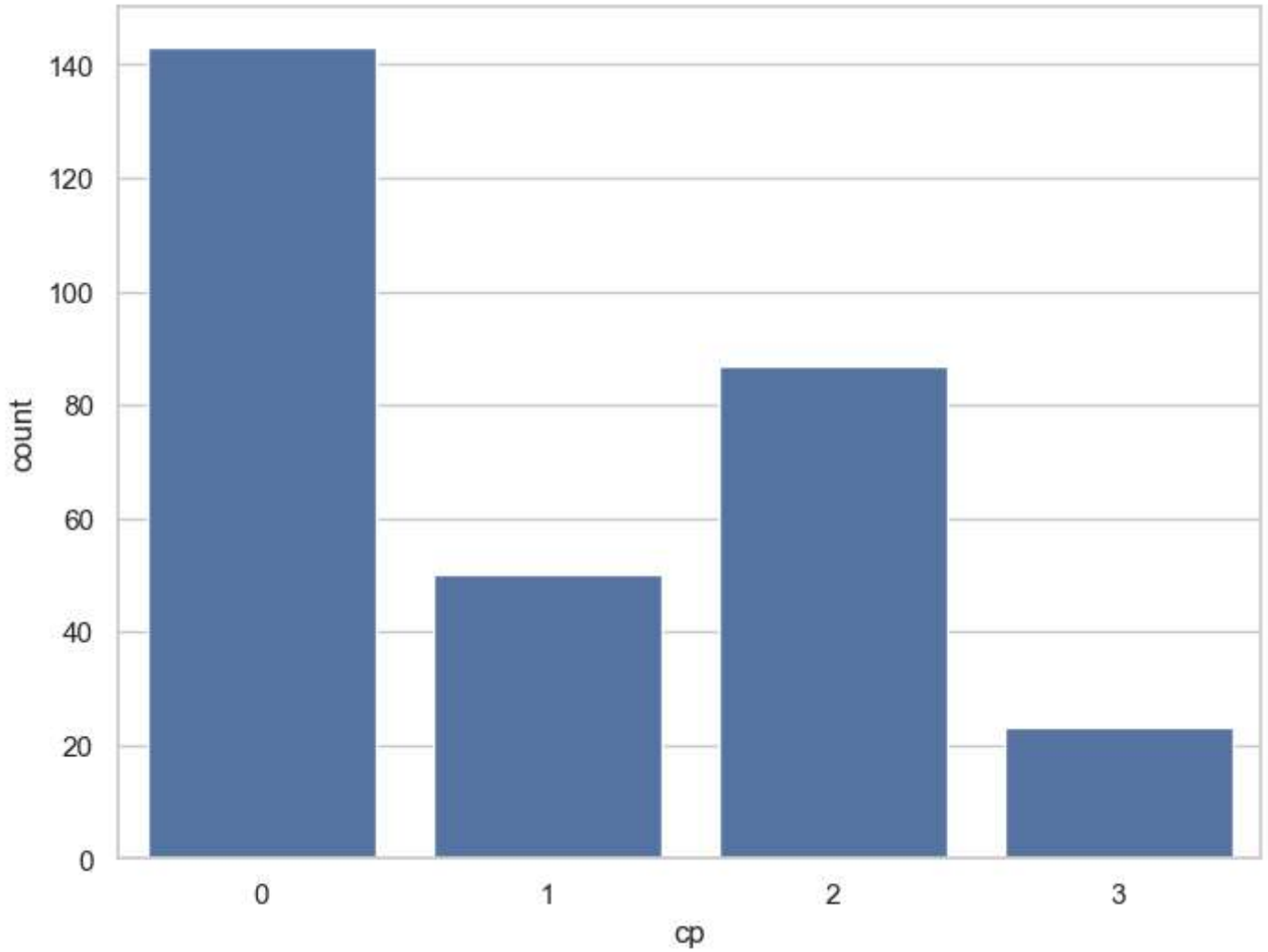
Out[38]:
```
4
```

In [39]:
```
df['cp'].value_counts()
```

Out[39]:
```
cp
0    143
2     87
1     50
3     23
Name: count, dtype: int64
```

visualize frequency distribution of cp variable

In [40]:
```
f, ax = plt.subplots(figsize=(8, 6))
ax = sns.countplot(x="cp", data=df)
plt.show()
```

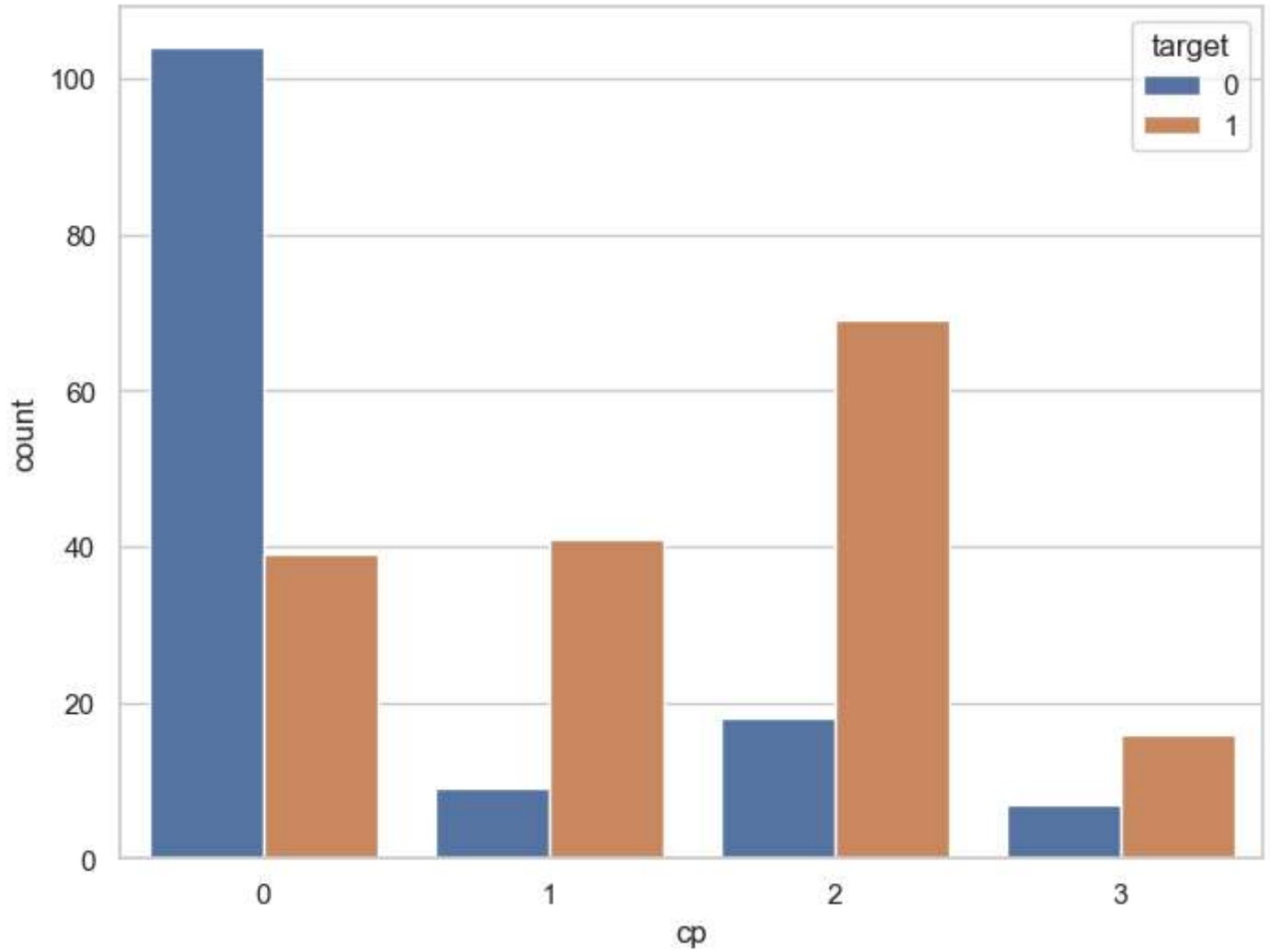


Frequency distribution of target variable wrt cp

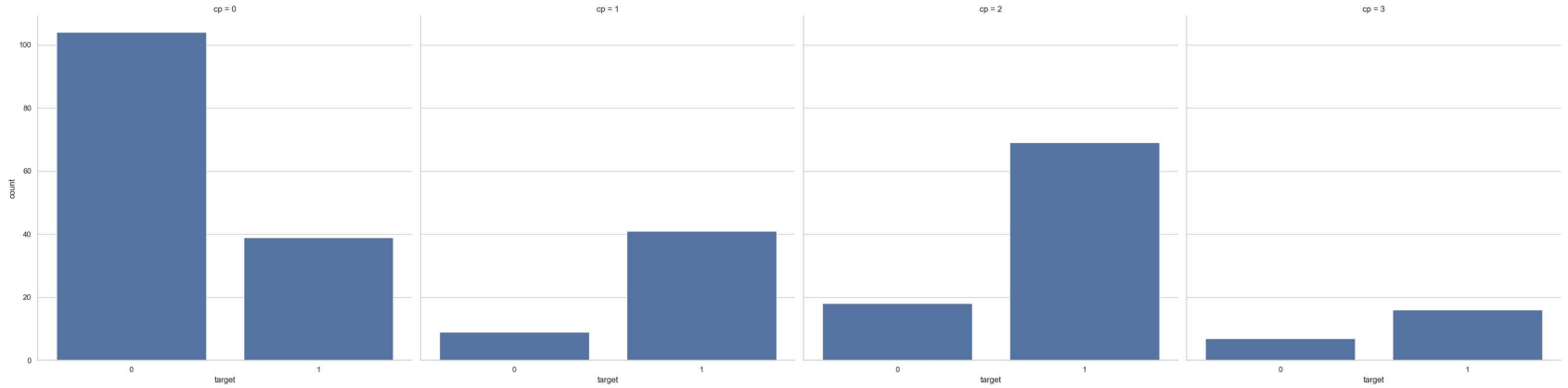
In [41]:
```
df.groupby('cp')['target'].value_counts()
```

Out[41]:
```
cp  target
0   0         104
    1          39
1   1          41
    0           9
2   1          69
    0          18
3   1          16
    0           7
Name: count, dtype: int64
```

In [42]:
```
f, ax = plt.subplots(figsize=(8, 6))
ax = sns.countplot(x="cp", hue="target", data=df)
plt.show()
```



In [43]:
```
ax = sns.catplot(x="target", col="cp", data=df, kind="count", height=8, aspect=1)
```



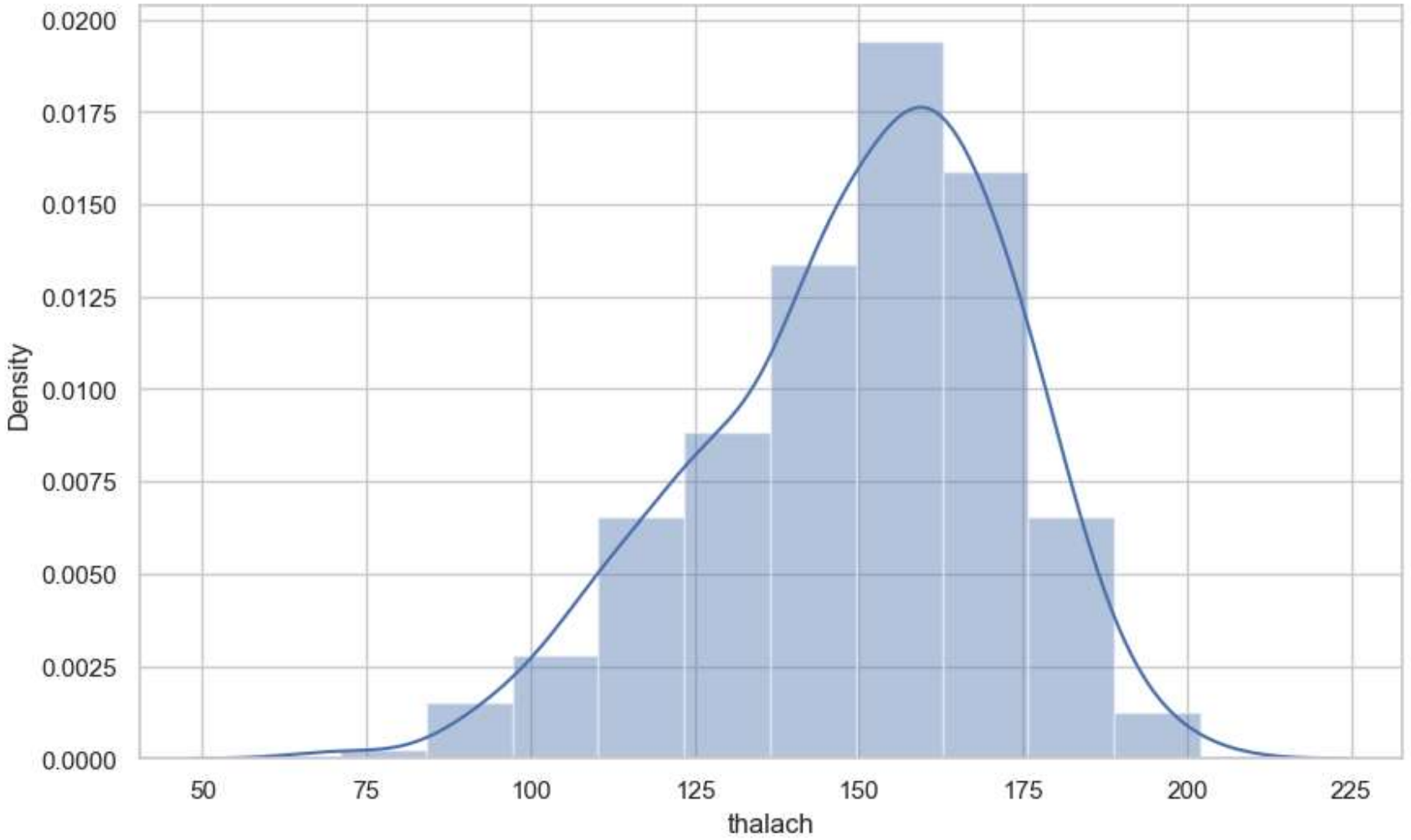
Analysis of `target` and `thalach` variable

In [44]:
```
df['thalach'].nunique()
```

Out[44]: 91

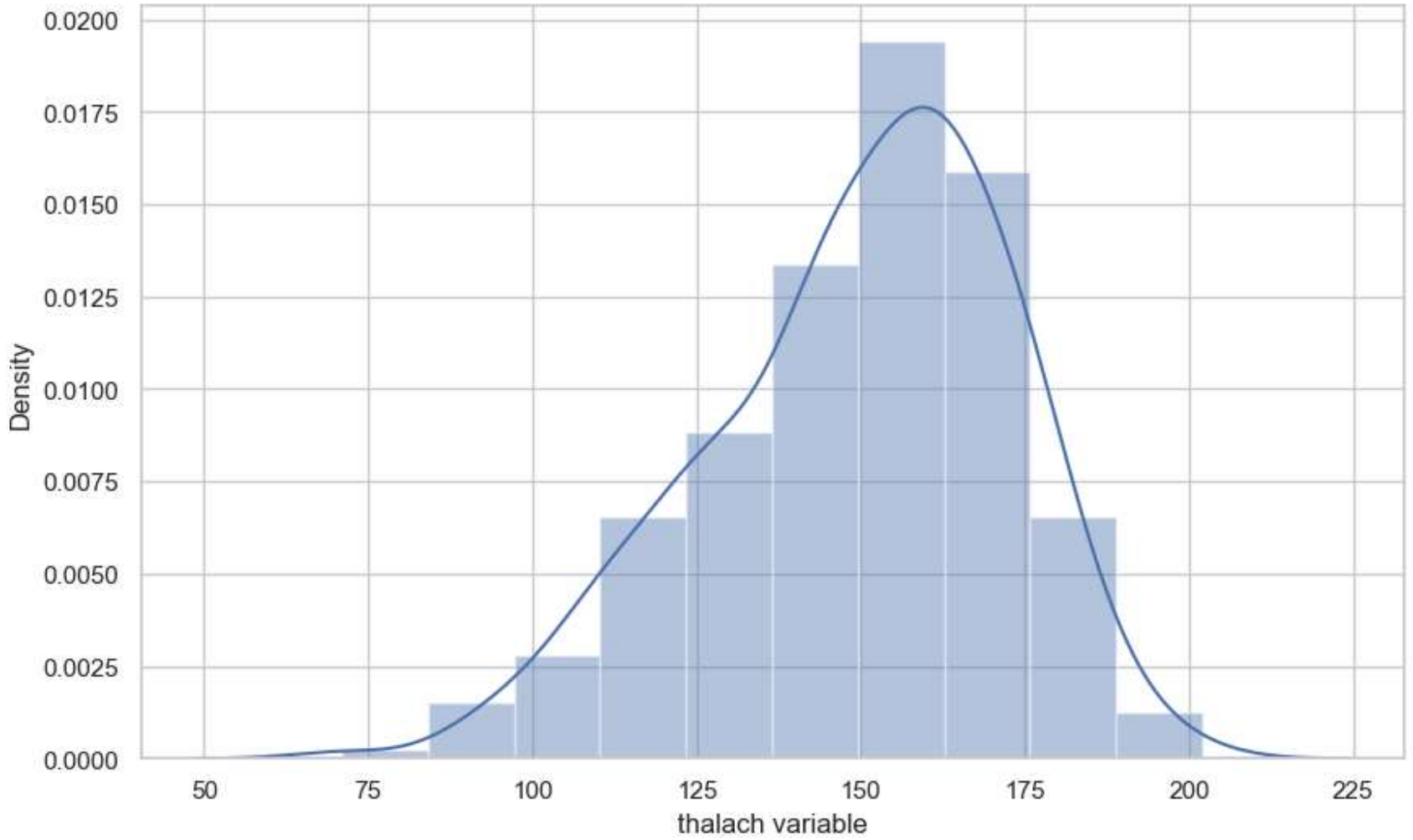
Visualize the frequency distribution of `thalach` variable

In [45]:
```
f, ax = plt.subplots(figsize=(10,6))
x = df['thalach']
ax = sns.distplot(x, bins=10)
plt.show()
```



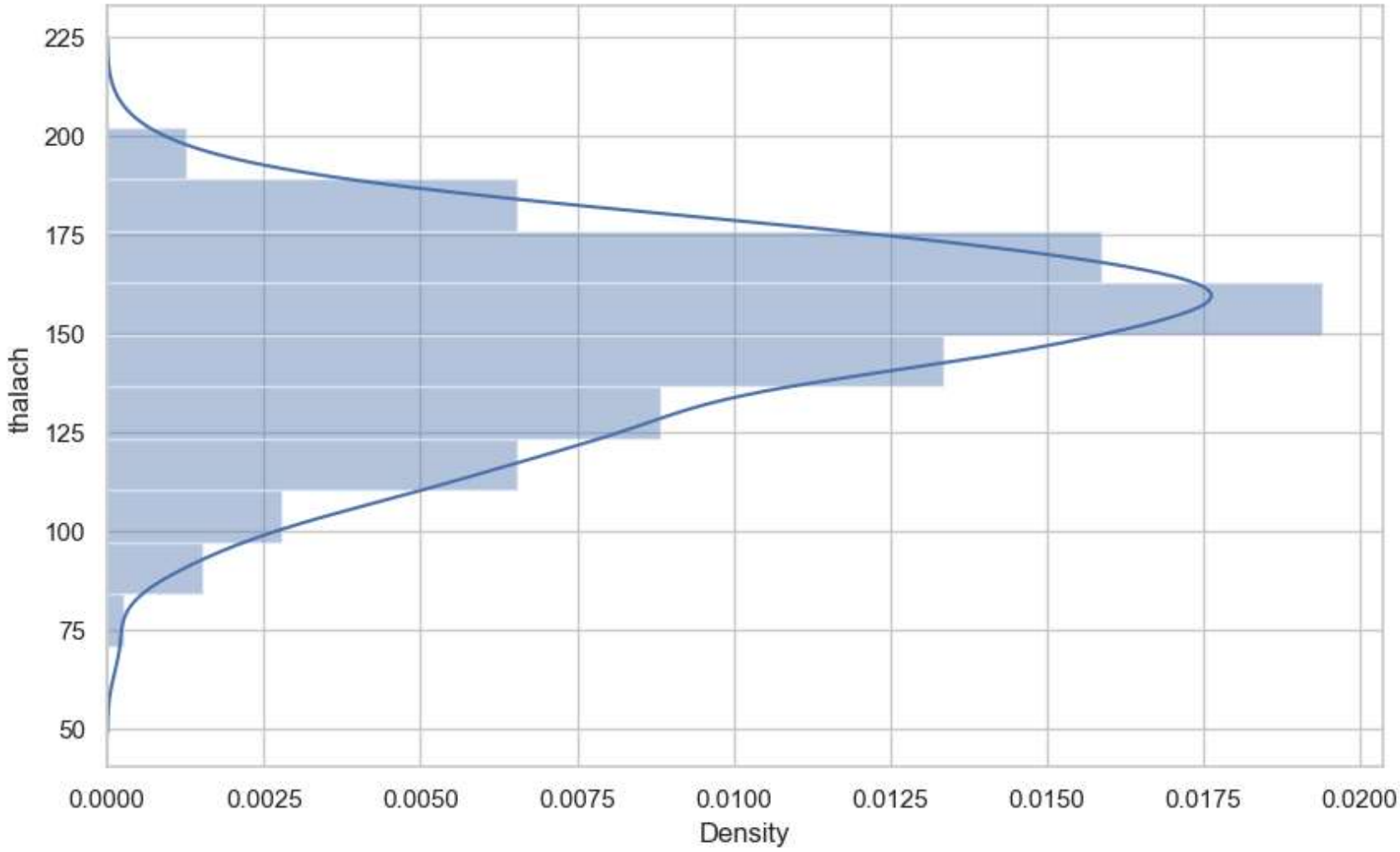
We can use Pandas series object to get an informative axis label as follows :

In [46]:
```
f, ax = plt.subplots(figsize=(10,6))
x = df['thalach']
x = pd.Series(x, name="thalach variable")
ax = sns.distplot(x, bins=10)
plt.show()
```



We can plot the distribution on the vertical axis as follows:-

In [47]:
```
f, ax = plt.subplots(figsize=(10,6))
x = df['thalach']
ax = sns.distplot(x, bins=10, vertical=True)
plt.show()
```

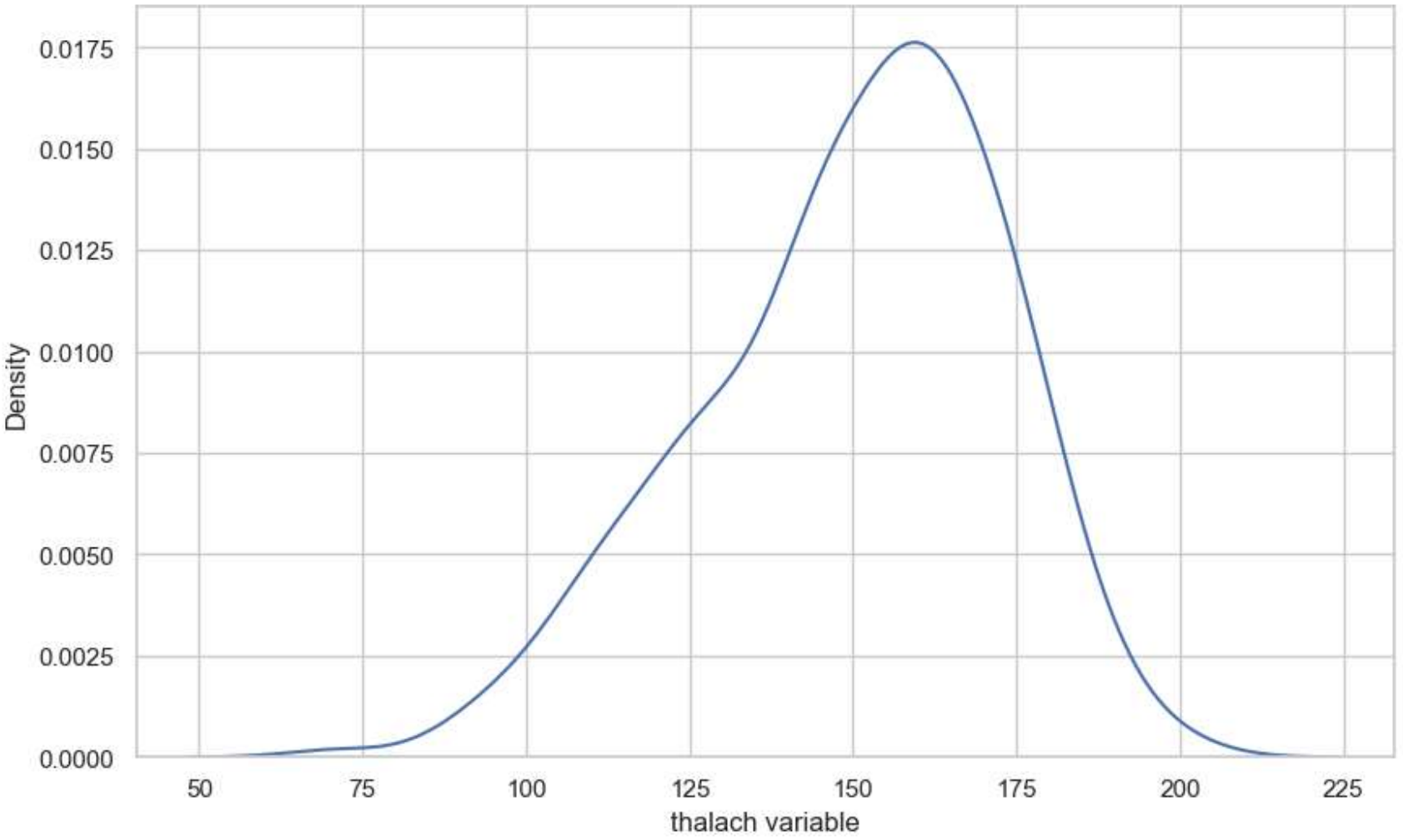


Seaborn Kernel Density Estimation (KDE) plot

- We can plot a KDE plot as follows :

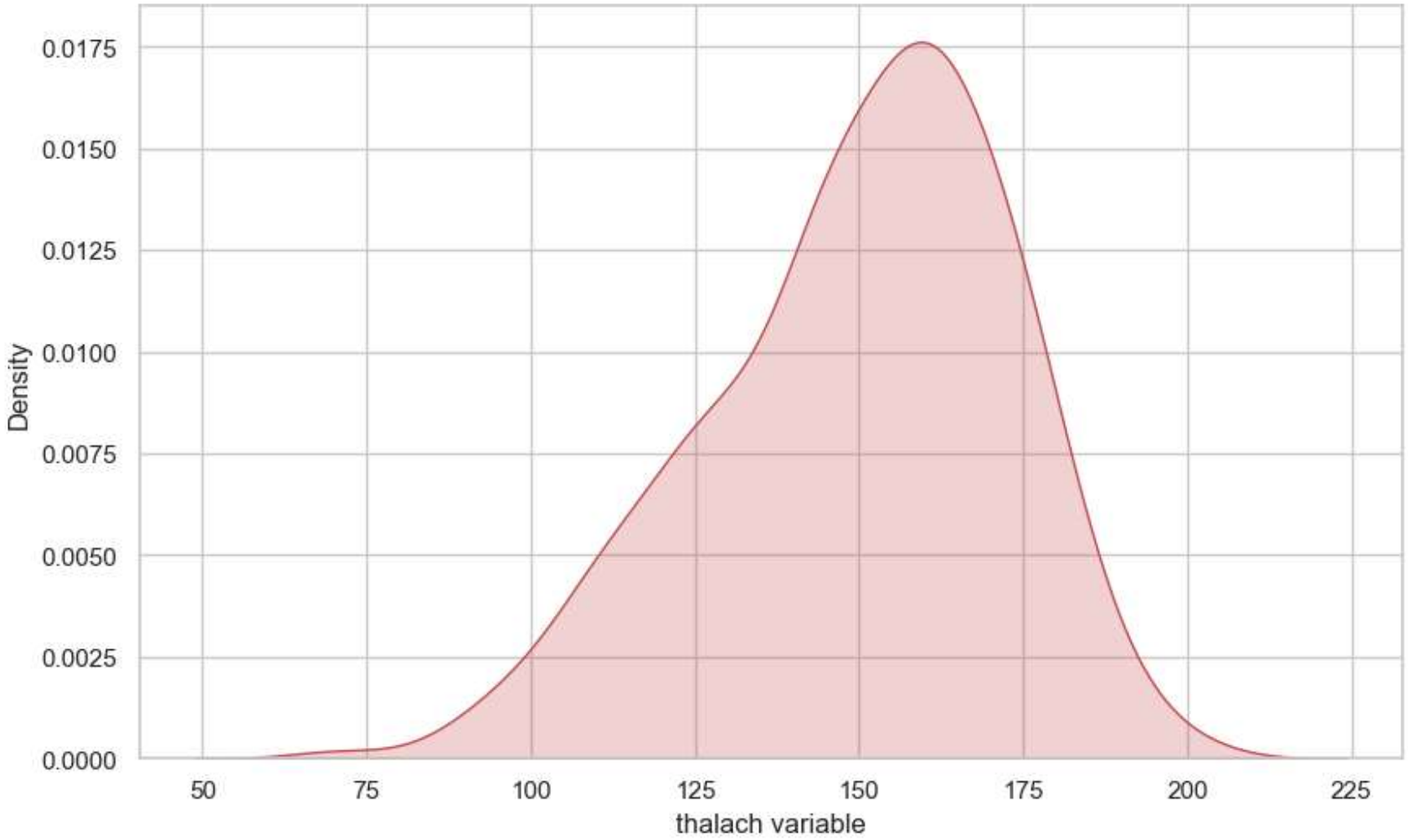
In [48]:
```
f, ax = plt.subplots(figsize=(10,6))
x = df['thalach']
x = pd.Series(x, name="thalach variable")
```

```
ax = sns.kdeplot(x)
plt.show()
```



We can shade under the density curve and use a different color as follows:

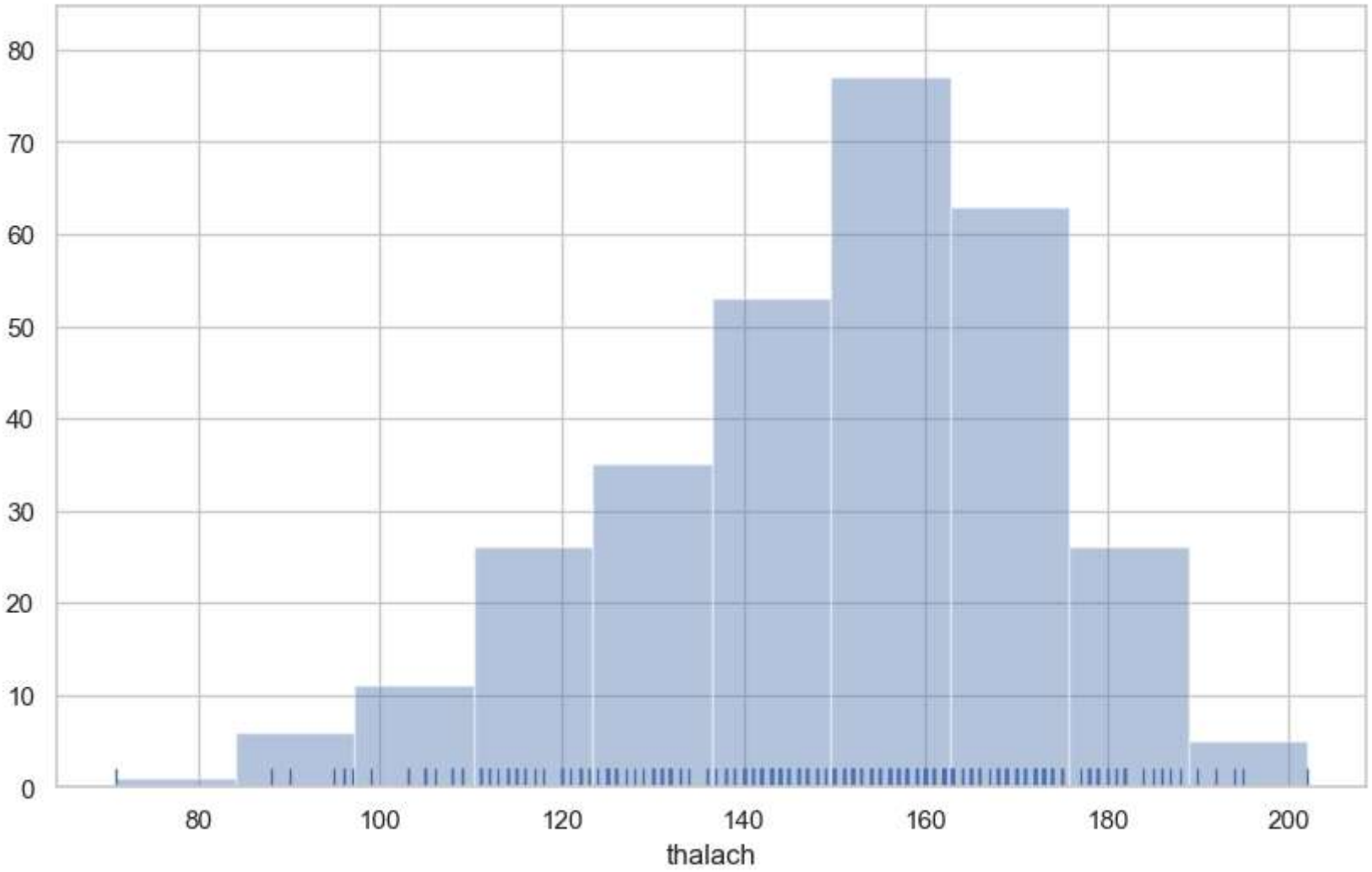
In [49]:
```
f, ax = plt.subplots(figsize=(10,6))
x = df['thalach']
x = pd.Series(x, name="thalach variable")
ax = sns.kdeplot(x, shade=True, color='r')
plt.show()
```



Histogram

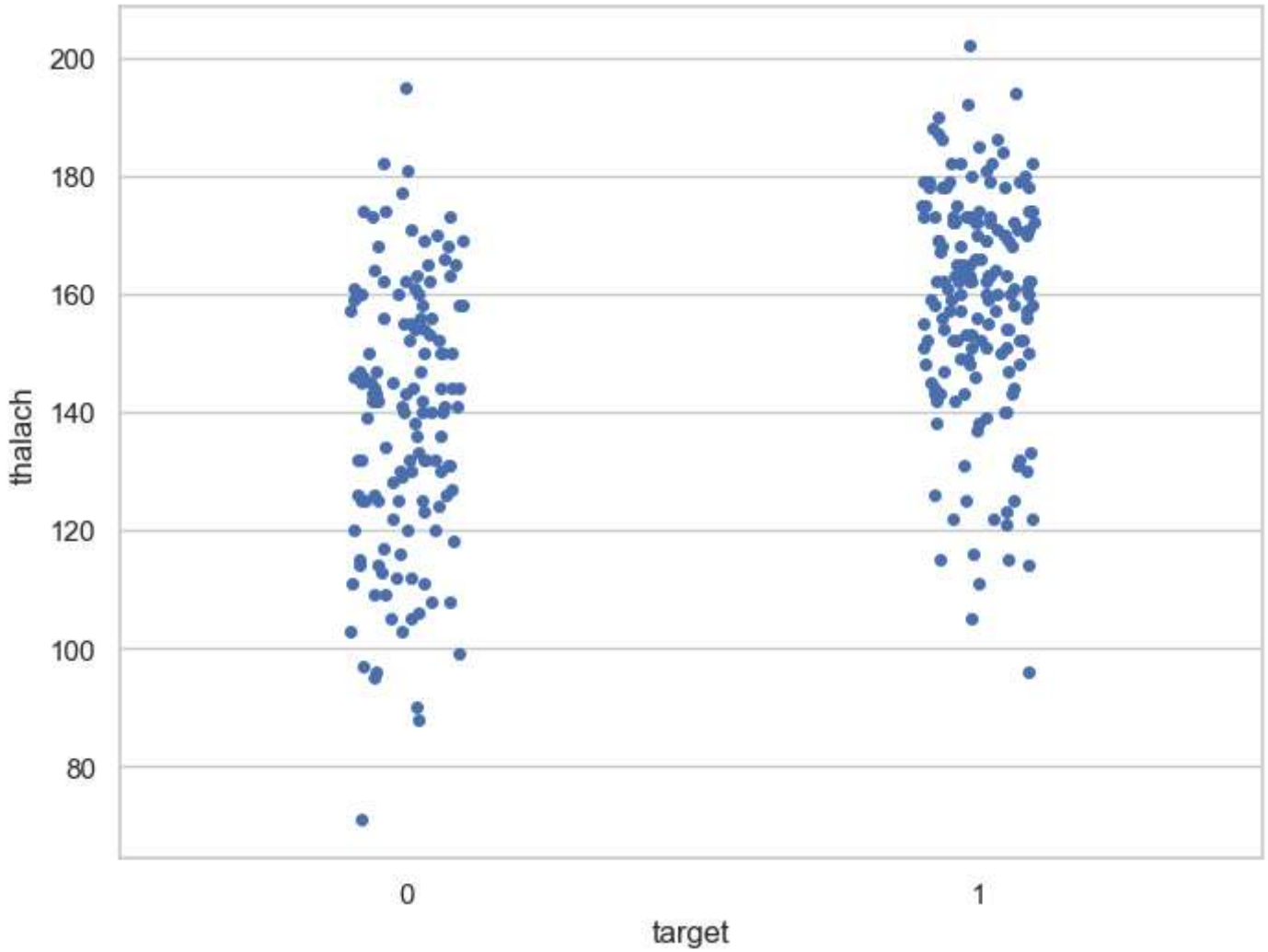
- We can plot a histogram as follows :

In [50]:
```
f, ax = plt.subplots(figsize=(10,6))
x = df['thalach']
ax = sns.distplot(x, kde=False, rug=True, bins=10)
plt.show()
```



Visualize frequency distribution of `thalach` variable wrt `target`

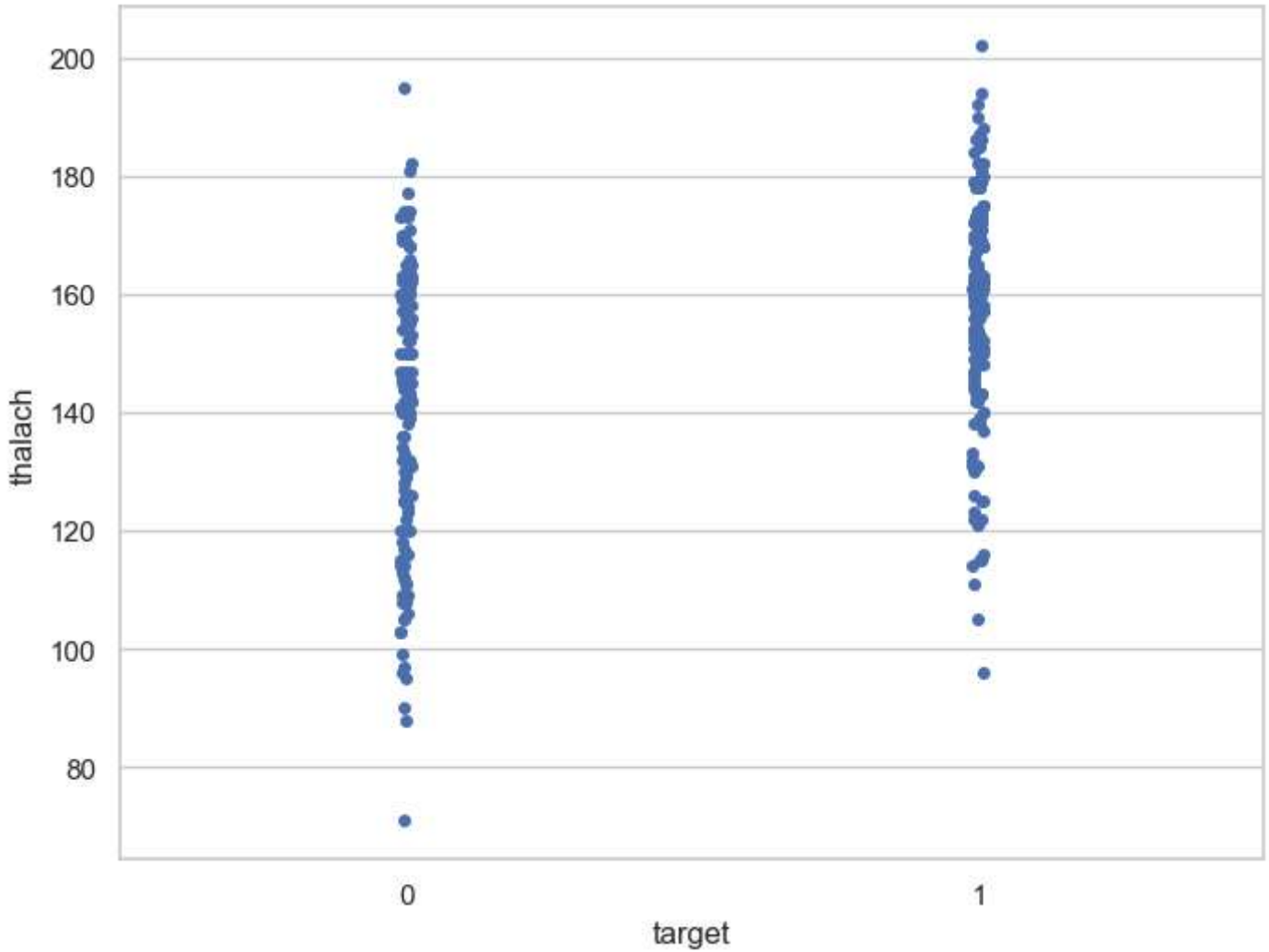
In [52]:
```
f, ax = plt.subplots(figsize=(8, 6))
sns.stripplot(x="target", y="thalach", data=df)
plt.show()
```



Interpretation

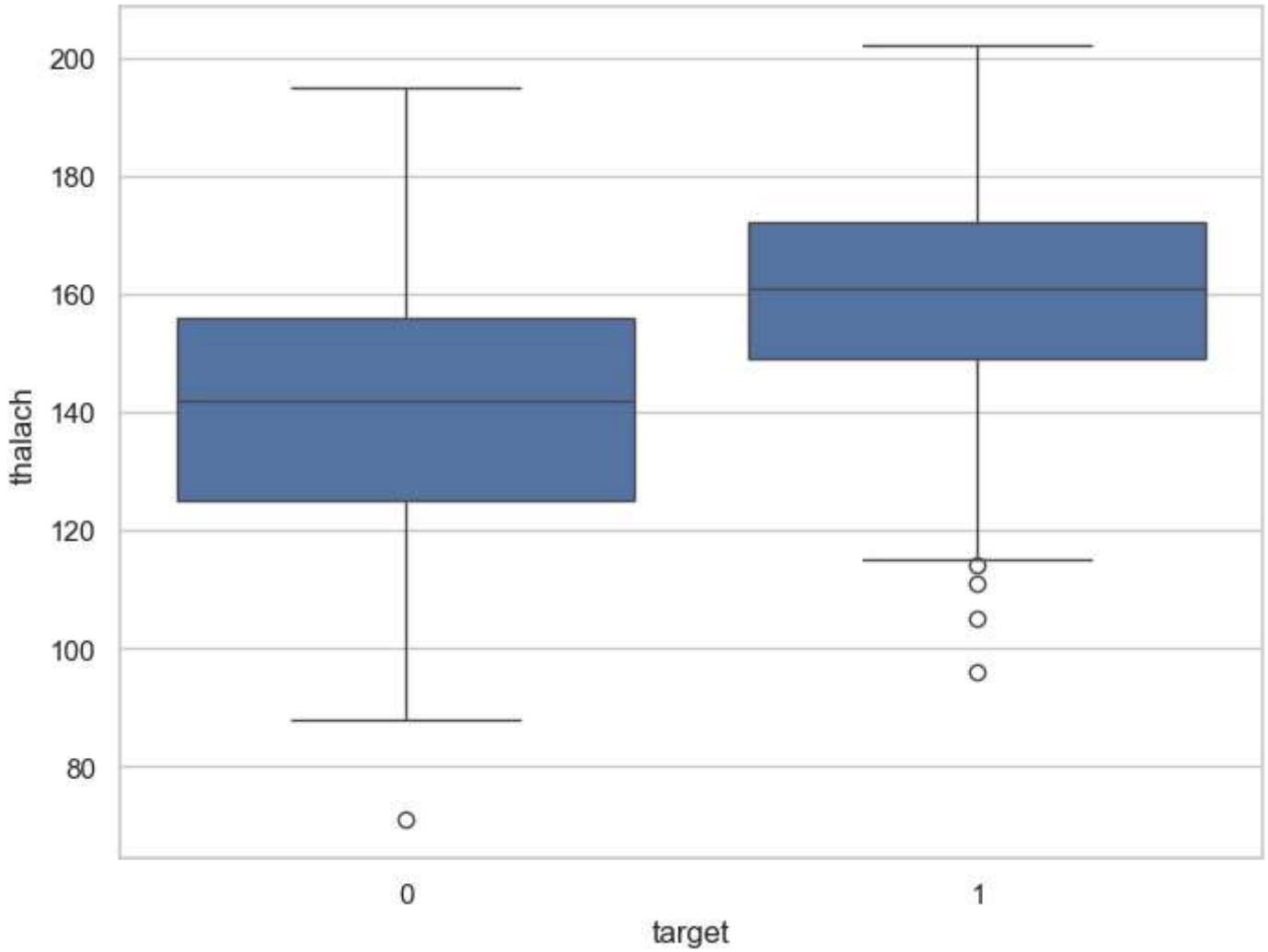
We can add jitter to bring out the distribution of values as follows :

In [53]:
```
f, ax = plt.subplots(figsize=(8, 6))
sns.stripplot(x="target", y="thalach", data=df, jitter = 0.01)
plt.show()
```



Visualize distribution of `thalach` variable wrt `target` with boxplot

In [54]:
```
f, ax = plt.subplots(figsize=(8, 6))
sns.boxplot(x="target", y="thalach", data=df)
plt.show()
```

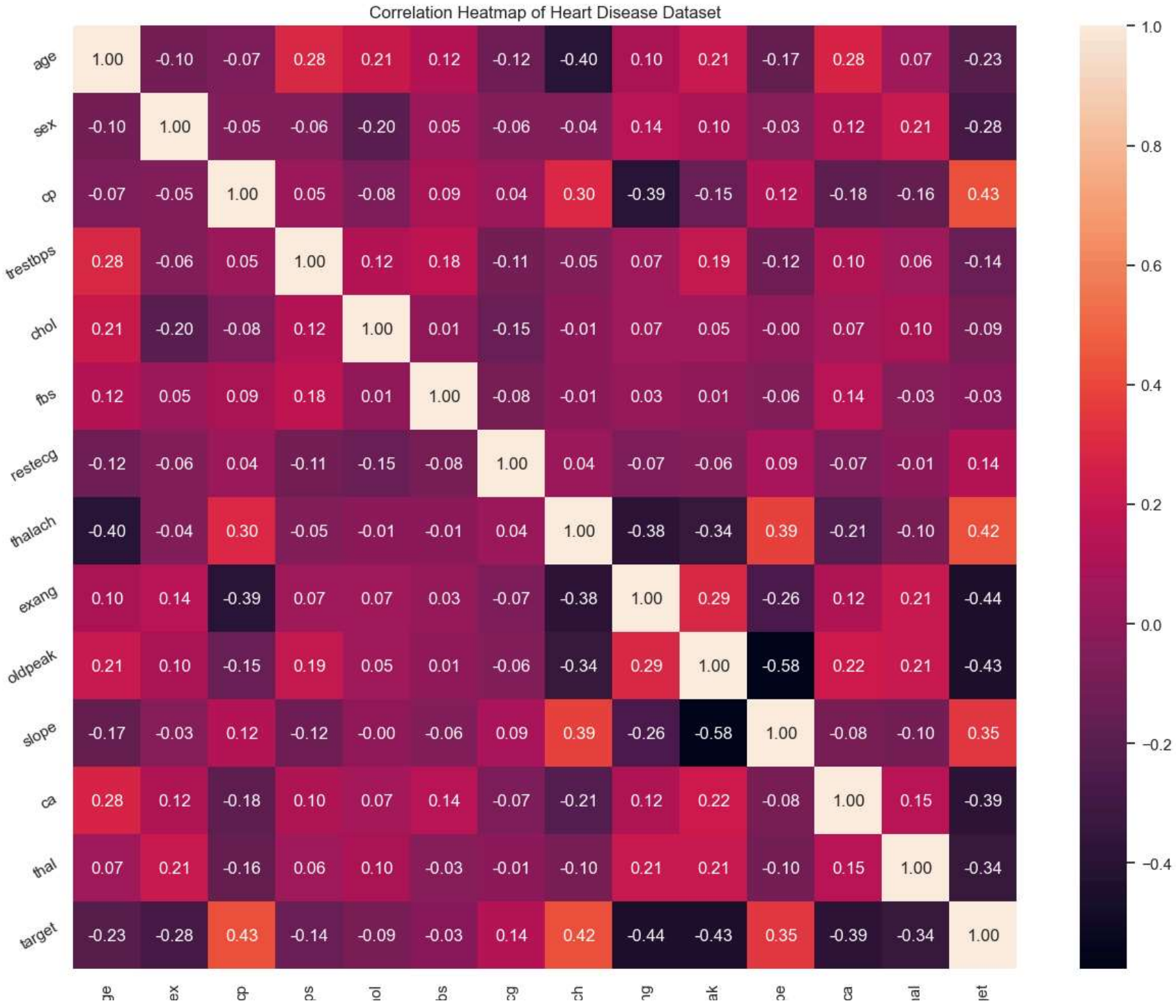


Multivariate analysis

Heat Map

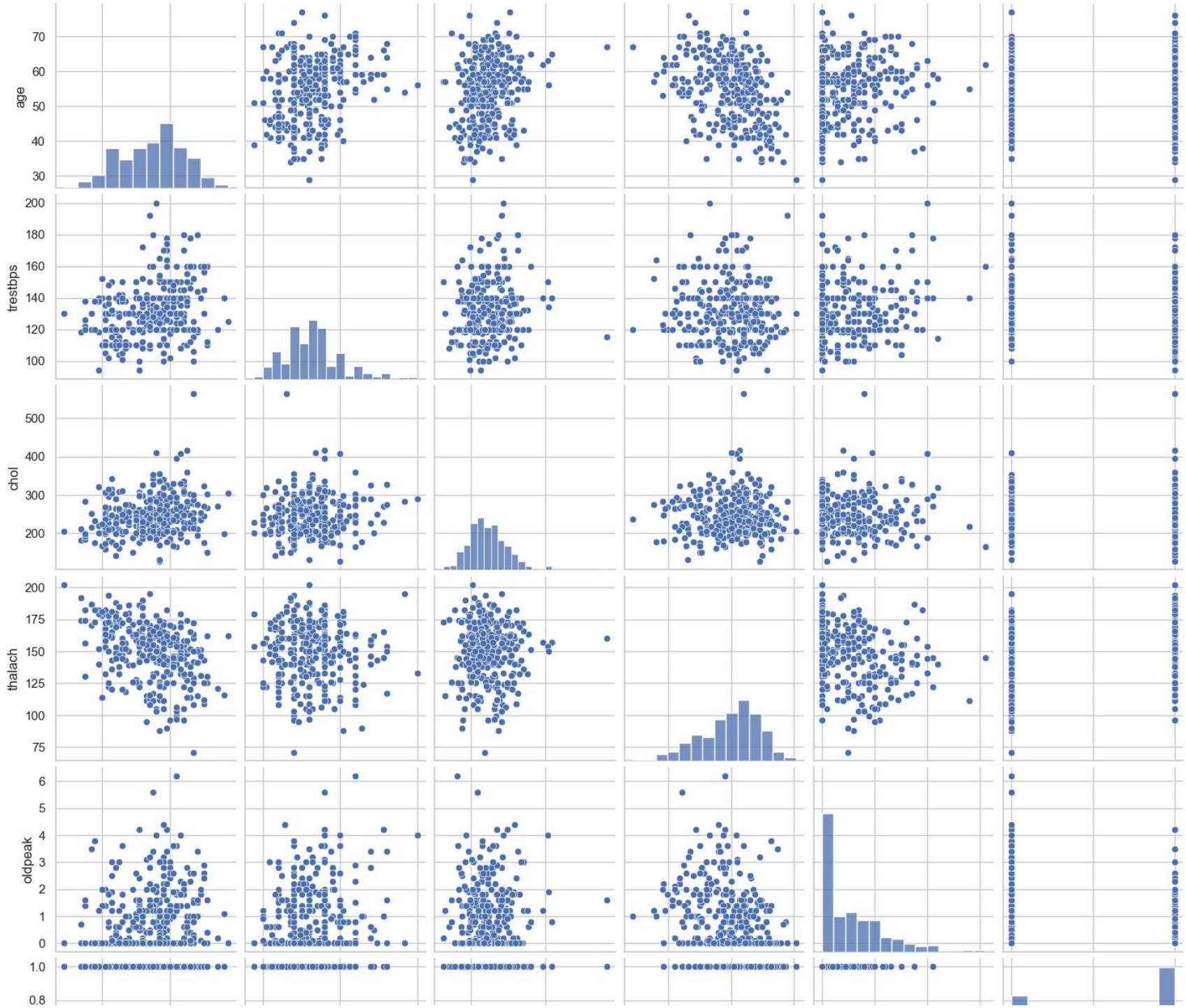
In [55]:
```
plt.figure(figsize=(16,12))
plt.title('Correlation Heatmap of Heart Disease Dataset')
a = sns.heatmap(correlation, square=True, annot=True, fmt='.2f', linecolor='white')
```

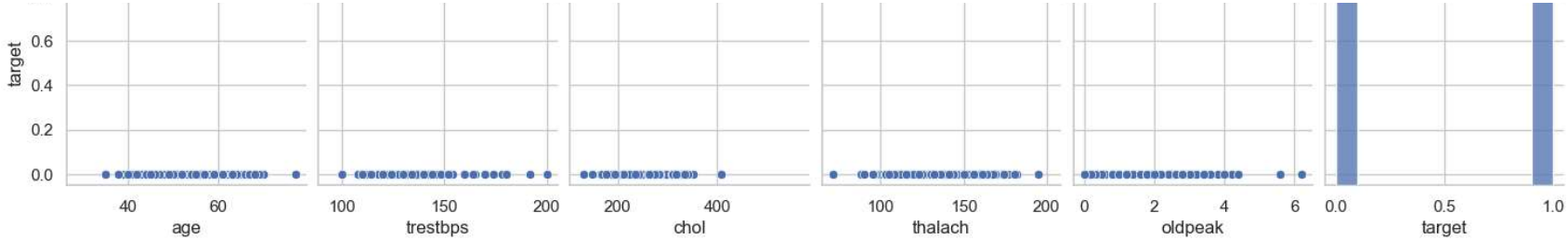
```
a.set_xticklabels(a.get_xticklabels(), rotation=90)
a.set_yticklabels(a.get_yticklabels(), rotation=30)
plt.show()
```


Correlation Heatmap of Heart Disease Dataset
age 1.00 -0.10 -0.07 0.28 0.21 0.12 -0.12 -0.40 0.10 0.21 -0.17 0.28 0.07 -0.23
sex -0.10 1.00 -0.05 -0.06 -0.20 0.05 -0.06 -0.04 0.14 0.10 -0.03 0.12 0.21 -0.28
cp -0.07 -0.05 1.00 0.05 -0.08 0.09 0.04 0.30 -0.39 -0.15 0.12 -0.18 -0.16 0.43
trestbps 0.28 -0.06 0.05 1.00 0.12 0.18 -0.11 -0.05 0.07 0.19 -0.12 0.10 0.06 -0.14
chol 0.21 -0.20 -0.08 0.12 1.00 0.01 -0.15 -0.01 0.07 0.05 -0.00 0.07 0.10 -0.09
fbs 0.12 0.05 0.09 0.18 0.01 1.00 -0.08 -0.01 0.03 0.01 -0.06 0.14 -0.03 -0.03
restecg -0.12 -0.06 0.04 -0.11 -0.15 -0.08 1.00 0.04 -0.07 -0.06 0.09 -0.07 -0.01 0.14
thalach -0.40 -0.04 0.30 -0.05 -0.01 -0.01 0.04 1.00 -0.38 -0.34 0.39 -0.21 -0.10 0.42
exang 0.10 0.14 -0.39 0.07 0.07 0.03 -0.07 -0.38 1.00 0.29 -0.26 0.12 0.21 -0.44
oldpeak 0.21 0.10 -0.15 0.19 0.05 0.01 -0.06 -0.34 0.29 1.00 -0.58 0.22 0.21 -0.43
slope -0.17 -0.03 0.12 -0.12 -0.00 -0.06 0.09 0.39 -0.26 -0.58 1.00 -0.08 -0.10 0.35
ca 0.28 0.12 -0.18 0.10 0.07 0.14 -0.07 -0.21 0.12 0.22 -0.08 1.00 0.15 -0.39
thal 0.07 0.21 -0.16 0.06 0.10 -0.03 -0.01 -0.10 0.21 0.21 -0.10 0.15 1.00 -0.34
target -0.23 -0.28 0.43 -0.14 -0.09 -0.03 0.14 0.42 -0.44 -0.43 0.35 -0.39 -0.34 1.00
ge ex cp ps ol bs cg ch ng ak pe ca al et
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4

Pair Plot

In [56]:
```
num_var = ['age', 'trestbps', 'chol', 'thalach', 'oldpeak', 'target' ]
sns.pairplot(df[num_var], kind='scatter', diag_kind='hist')
plt.show()
```


age
trestbps
chol
thalach
oldpeak
70
60
50
40
30
200
180
160
140
120
100
500
400
300
200
200
175
150
125
100
75
6
5
4
3
2
1
0
1.0
0.8



Analysis of `age` and other variables

Check the number of unique values in `age` variable

In [57]:
```
df['age'].nunique()
```

Out[57]:
```
41
```

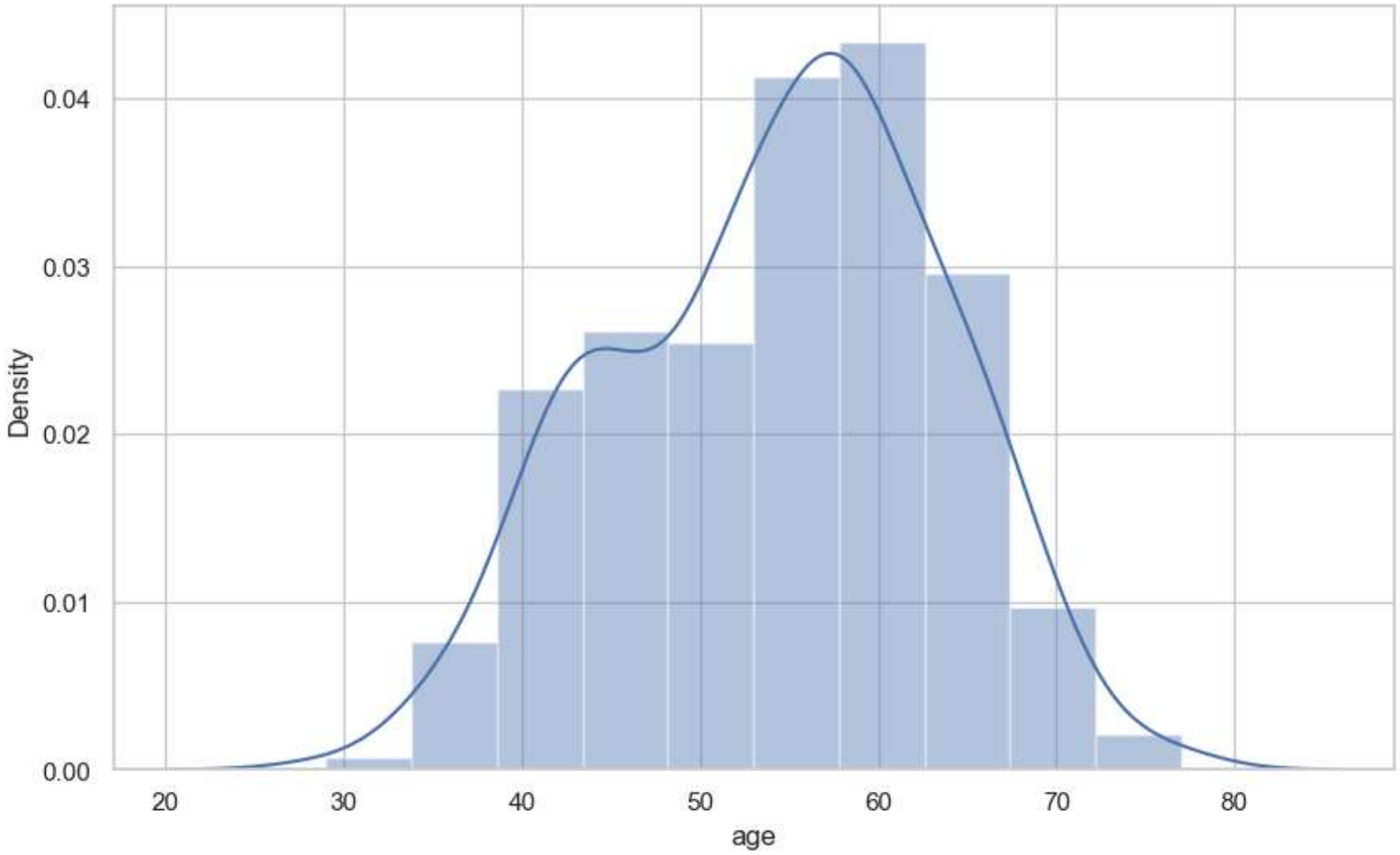
View statistical summary of `age` variable

In [58]:
```
df['age'].describe()
```

Out[58]:
```
count    303.000000
mean      54.366337
std        9.082101
min       29.000000
25%       47.500000
50%       55.000000
75%       61.000000
max       77.000000
Name: age, dtype: float64
```

Plot the distribution of `age` variable

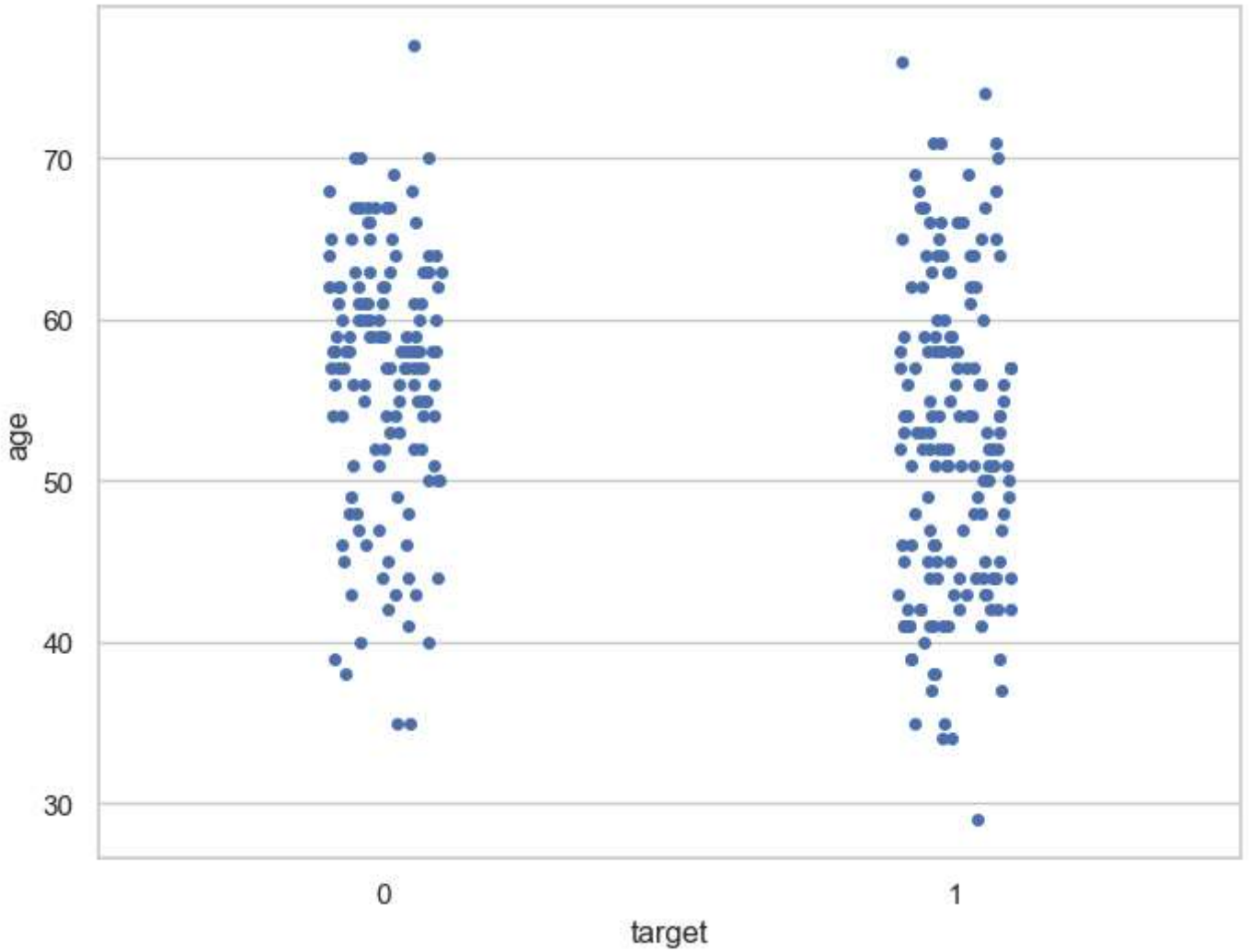
In [59]:
```
f, ax = plt.subplots(figsize=(10,6))
x = df['age']
ax = sns.distplot(x, bins=10)
plt.show()
```



Analyze `age` and `target` variable

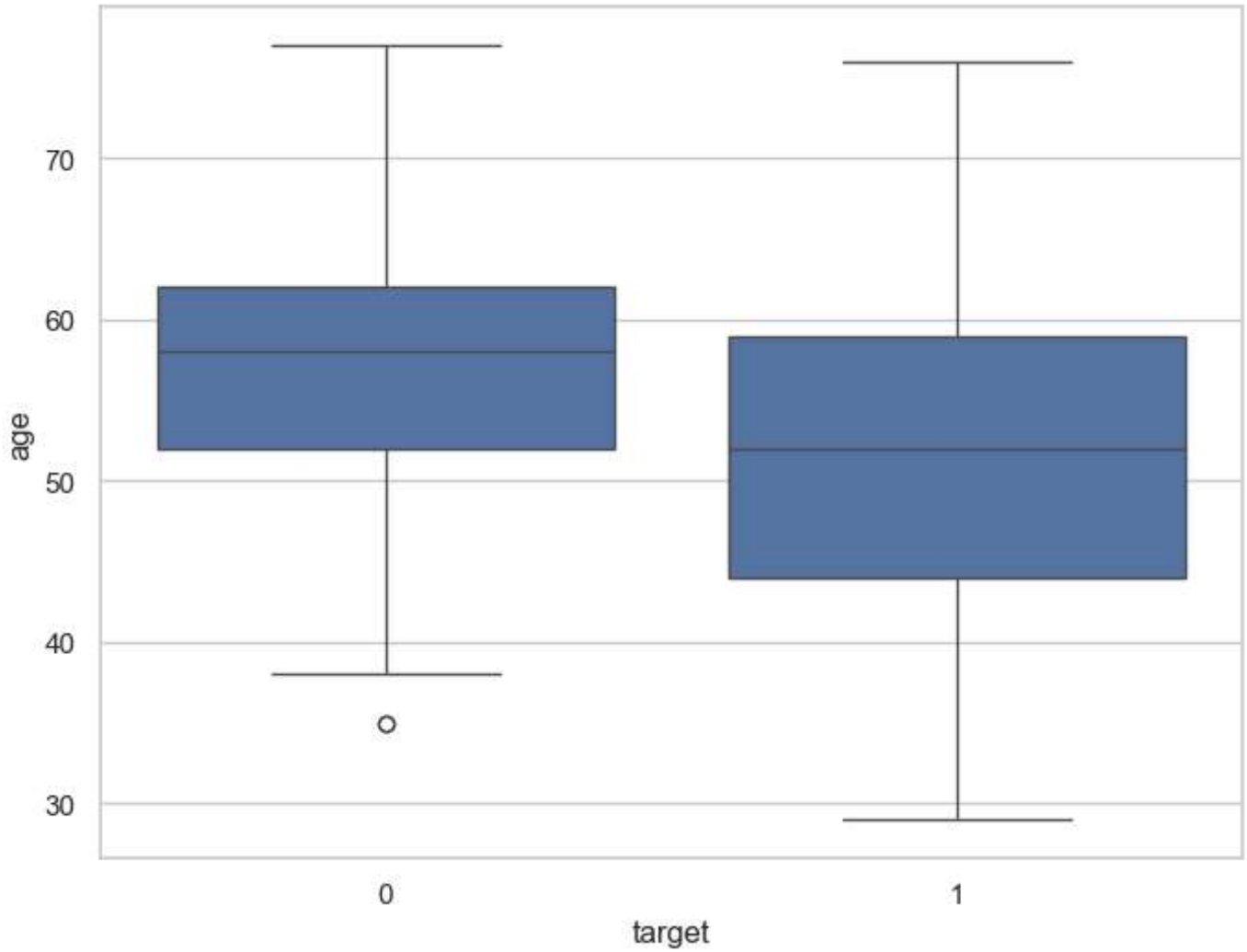
Visualize frequency distribution of `age` variable wrt `target`

In [60]:
```
f, ax = plt.subplots(figsize=(8, 6))
sns.stripplot(x="target", y="age", data=df)
plt.show()
```



Visualize distribution of `age` variable wrt `target` with boxplot

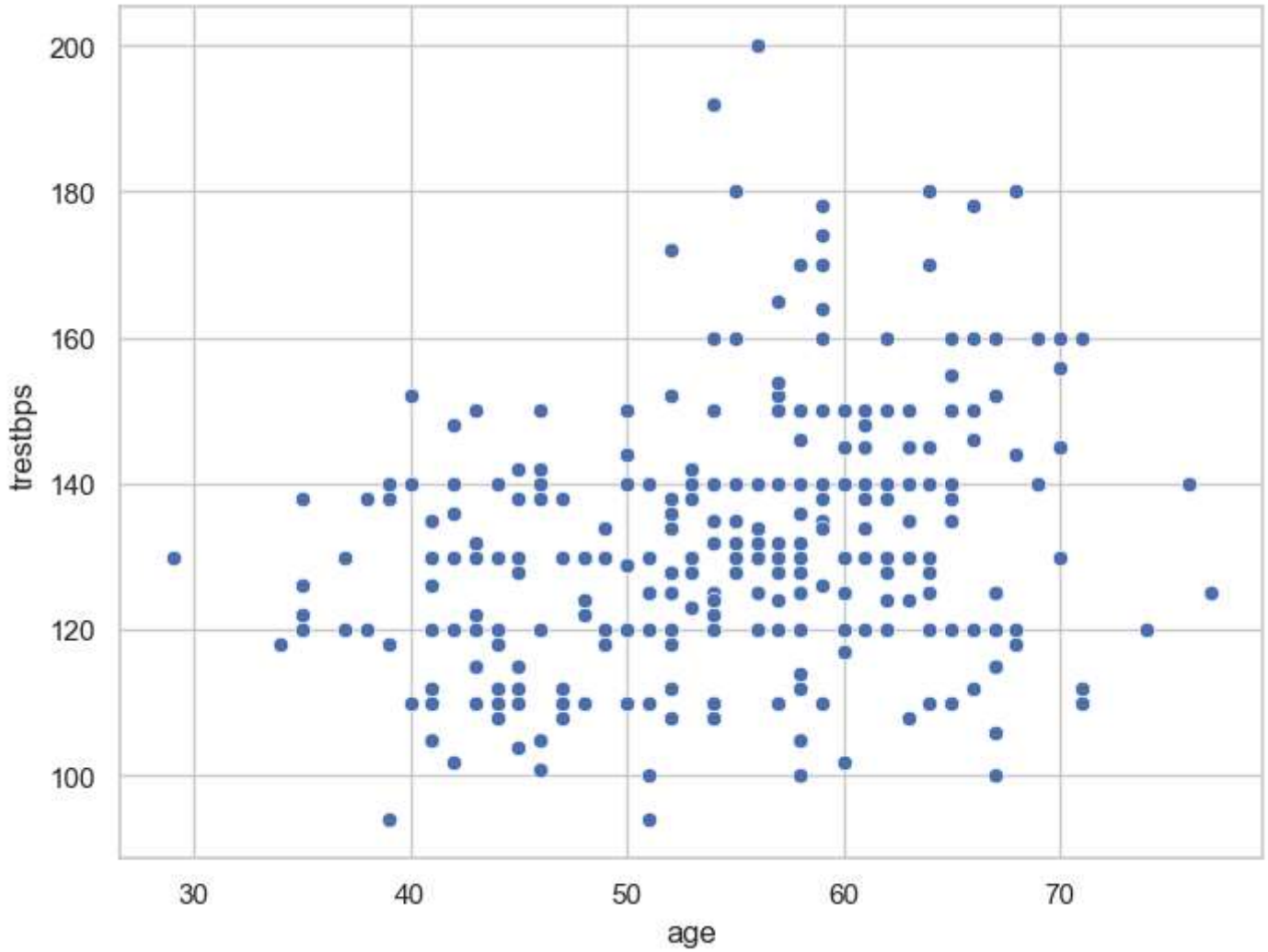
In [61]:
```
f, ax = plt.subplots(figsize=(8, 6))
sns.boxplot(x="target", y="age", data=df)
plt.show()
```



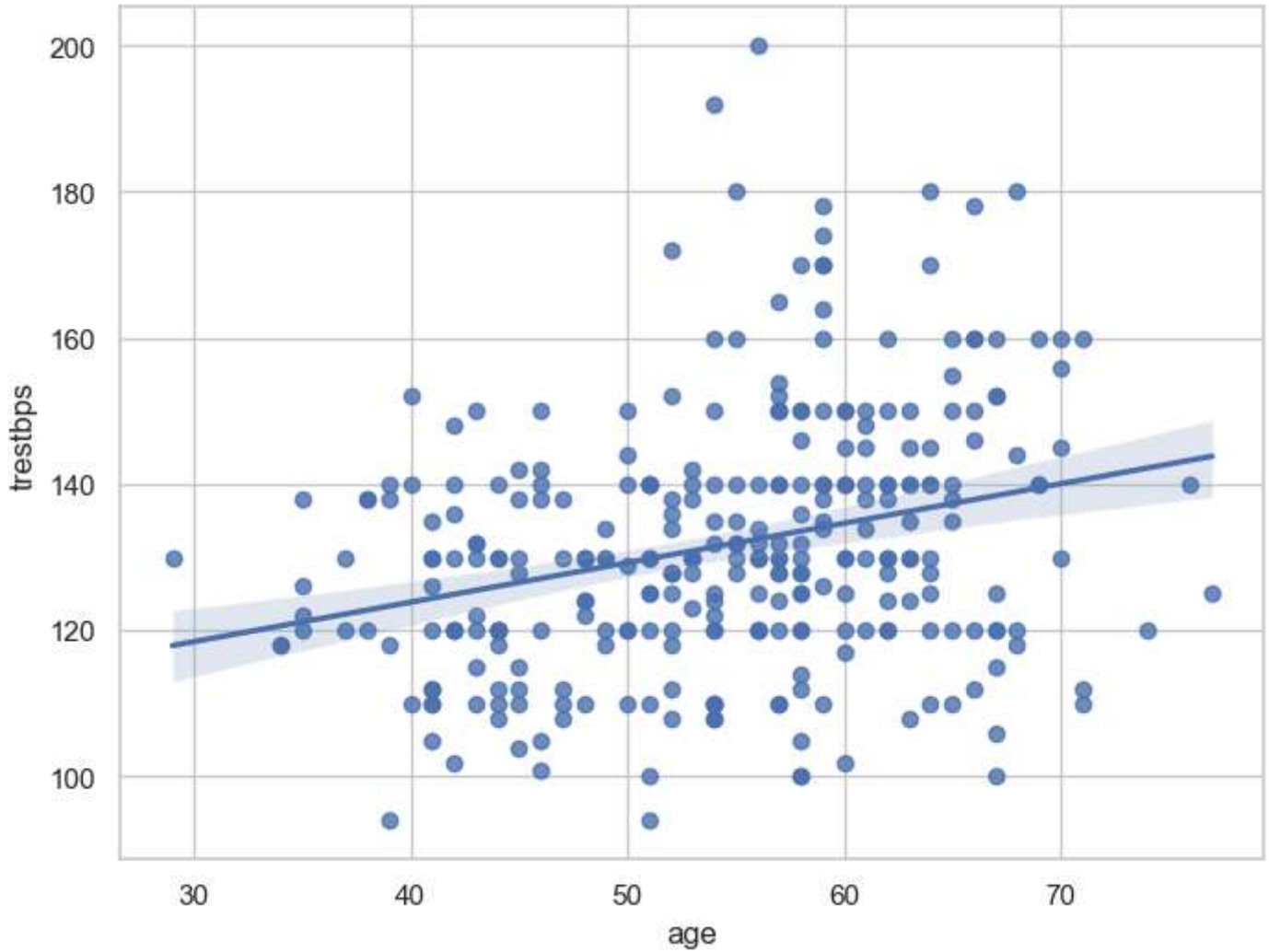
Analyze `age` and `trestbps` variable

I will plot a scatterplot to visualize the relationship between `age` and `trestbps` variable.

In [62]:
```
f, ax = plt.subplots(figsize=(8, 6))
ax = sns.scatterplot(x="age", y="trestbps", data=df)
plt.show()
```

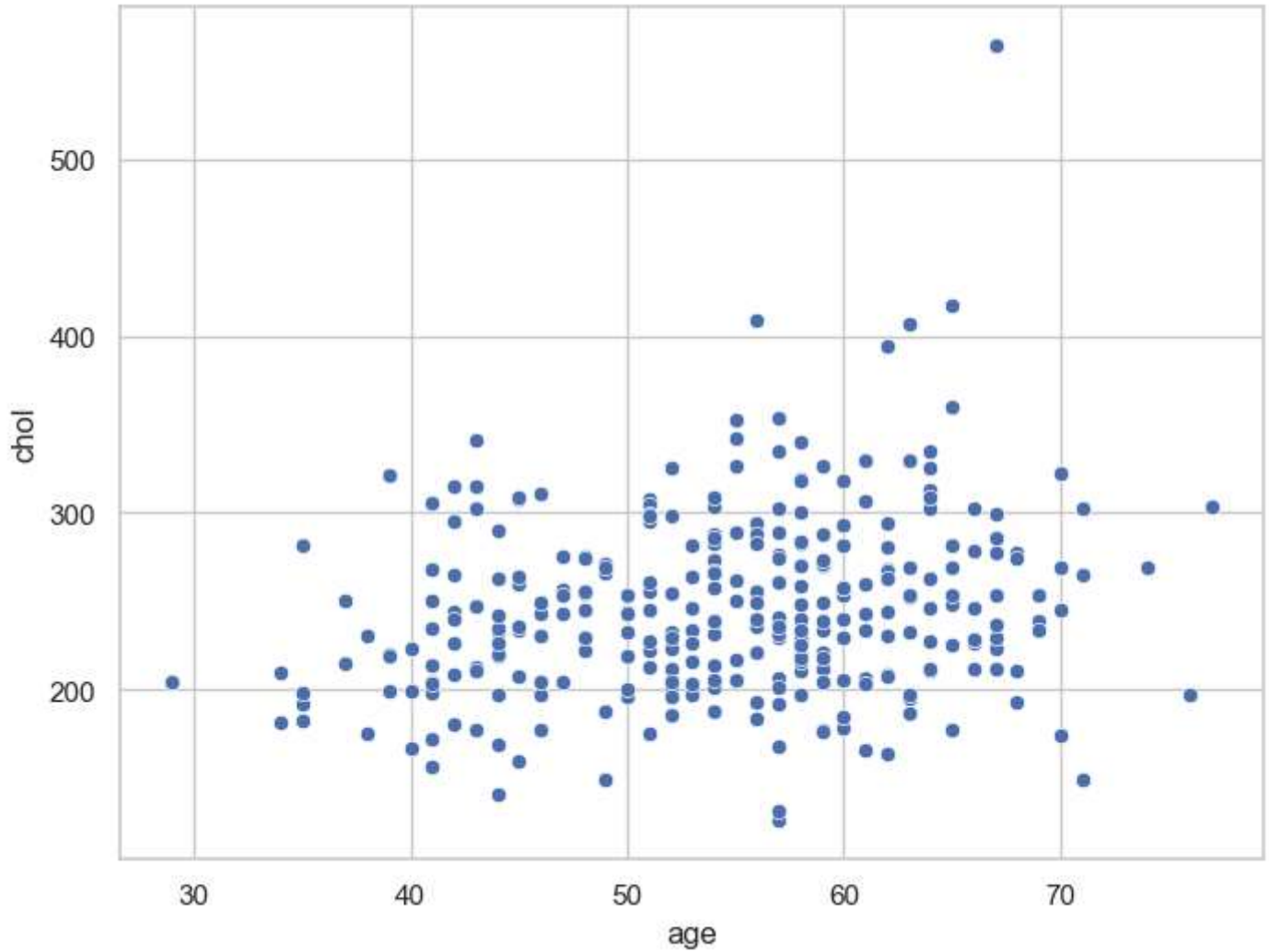


In [63]:
```
f, ax = plt.subplots(figsize=(8, 6))
ax = sns.regplot(x="age", y="trestbps", data=df)
plt.show()
```

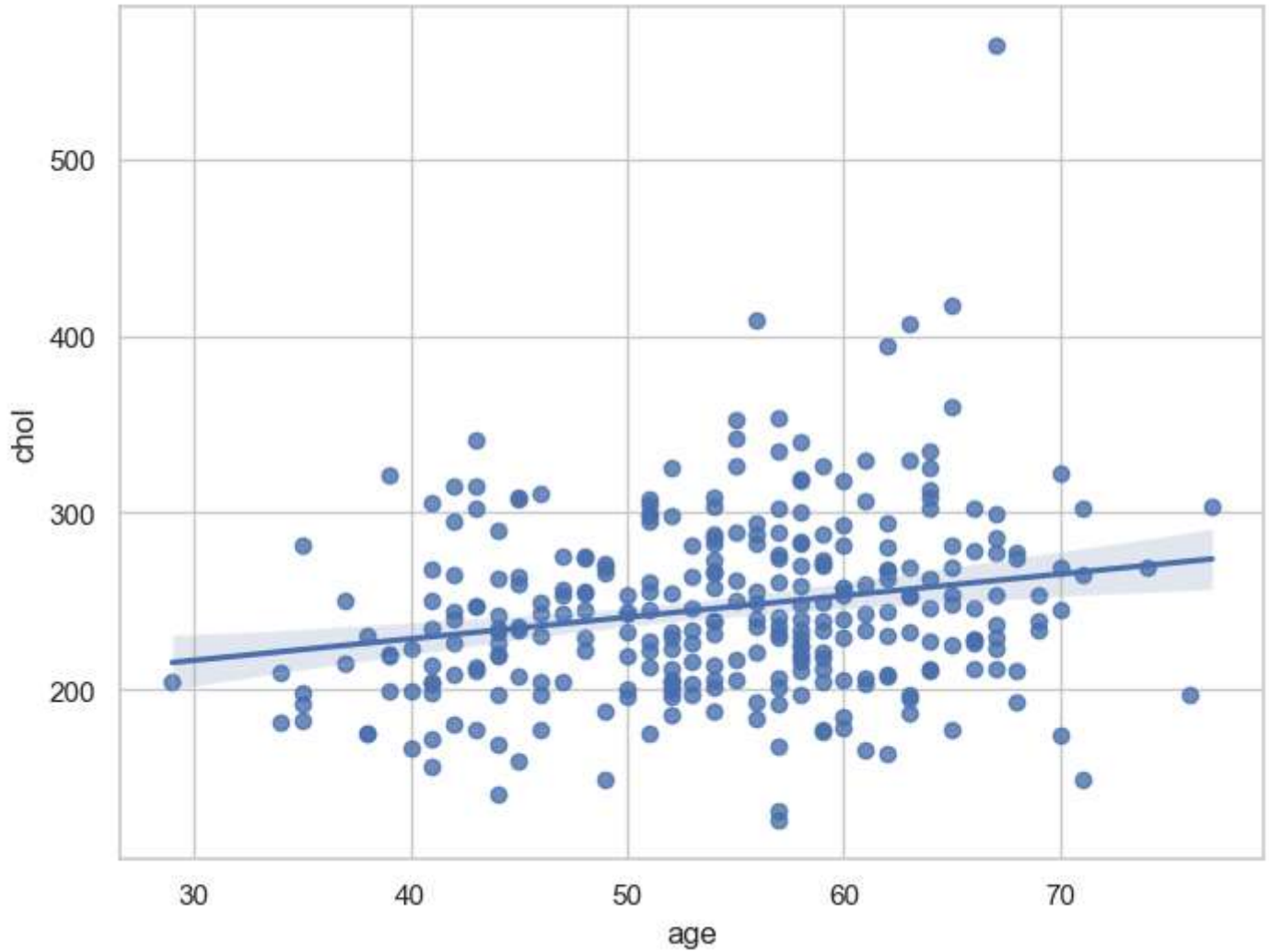


Analyze `age` and `chol` variable

In [64]:
```
f, ax = plt.subplots(figsize=(8, 6))
ax = sns.scatterplot(x="age", y="chol", data=df)
plt.show()
```

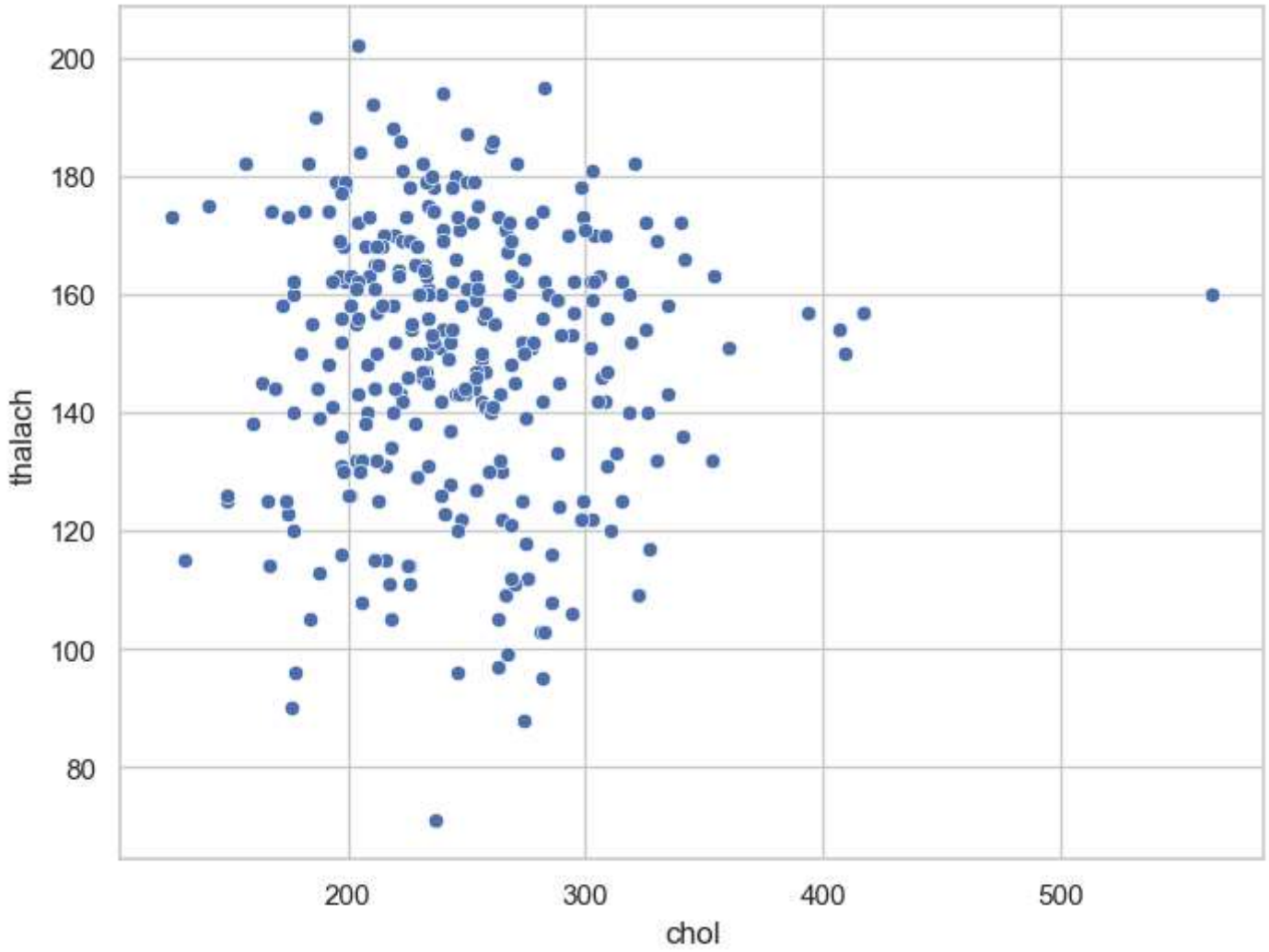


In [65]:
```
f, ax = plt.subplots(figsize=(8, 6))
ax = sns.regplot(x="age", y="chol", data=df)
plt.show()
```

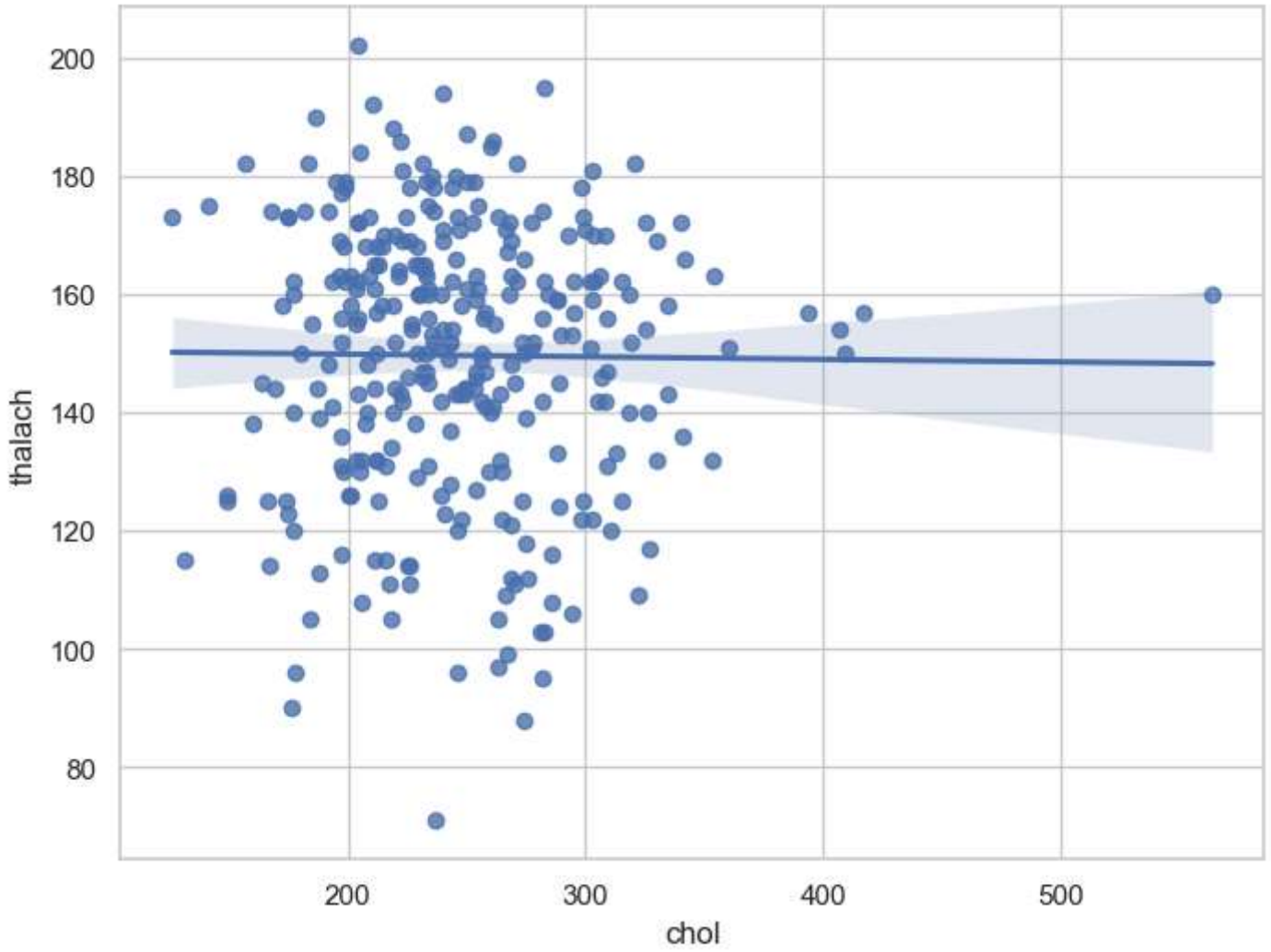


Analyze `chol` and `thalach` variable

In [66]:
```
f, ax = plt.subplots(figsize=(8, 6))
ax = sns.scatterplot(x="chol", y = "thalach", data=df)
plt.show()
```



In [67]:
```
f, ax = plt.subplots(figsize=(8, 6))
ax = sns.regplot(x="chol", y="thalach", data=df)
plt.show()
```



Dealing with missing values

Pandas isnull() and notnull() functions

In [68]:
```
# check for missing values

df.isnull().sum()
```

Out[68]:
```
age         0
sex         0
cp          0
trestbps    0
chol        0
fbs         0
restecg     0
thalach     0
exang       0
oldpeak     0
slope       0
ca          0
thal        0
target      0
dtype: int64
```

Check with ASSERT statement

In [69]:
```
#assert that there are no missing values in the dataframe

assert pd.notnull(df).all().all()
```

In [70]:
```
#assert all values are greater than or equal to 0

assert (df >= 0).all().all()
```

12. Outlier detection

I will make boxplots to visualise outliers in the continuous numerical variables : -

`age` , `trestbps` , `chol` , `thalach` and `oldpeak` variables.

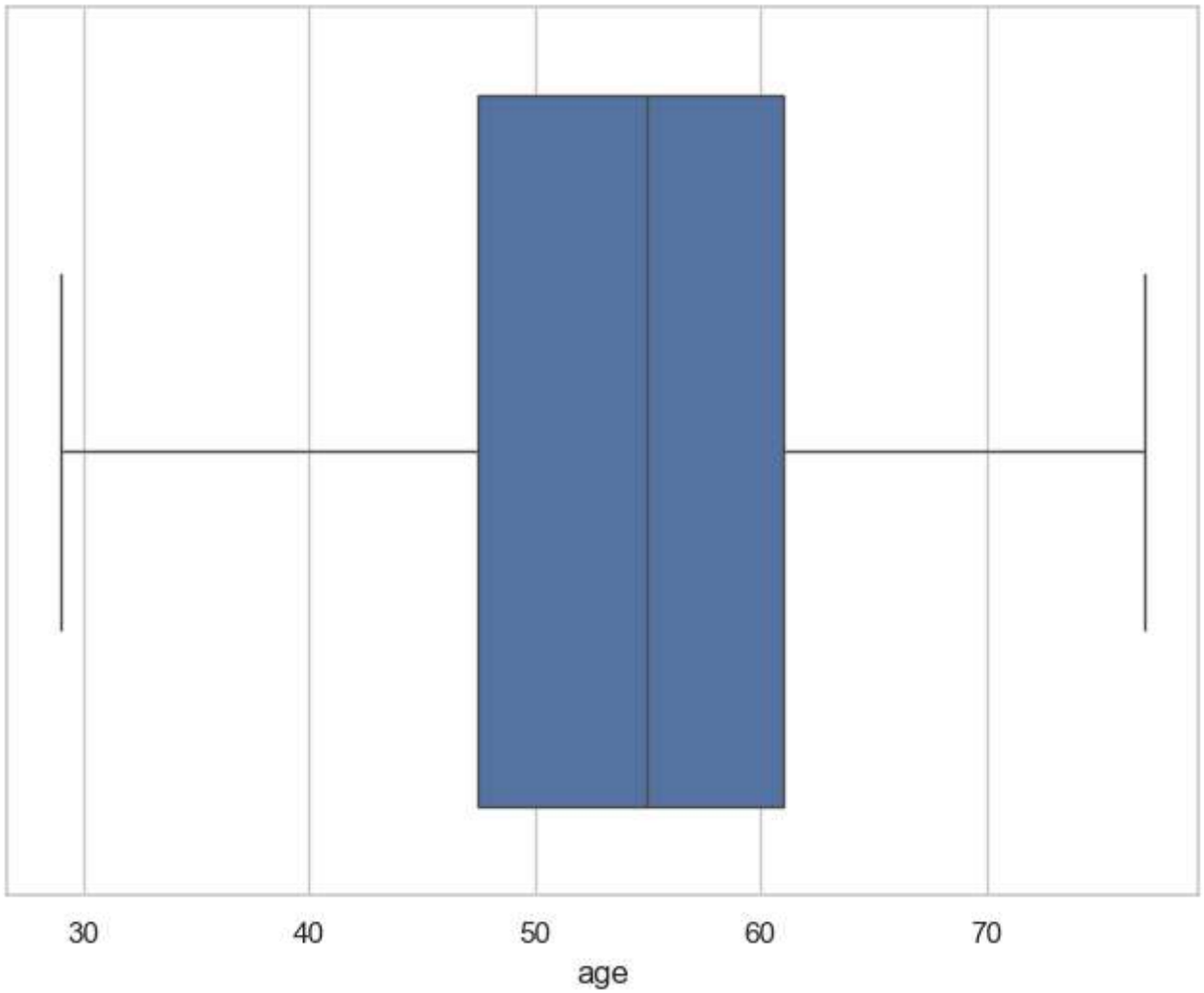
`age` variable

In [71]:
```
df['age'].describe()
```

Out[71]:
```
count    303.000000
mean      54.366337
std        9.082101
min       29.000000
25%       47.500000
50%       55.000000
75%       61.000000
max       77.000000
Name: age, dtype: float64
```

Box-plot of `age` variable

In [72]:
```
f, ax = plt.subplots(figsize=(8, 6))
sns.boxplot(x=df["age"])
plt.show()
```



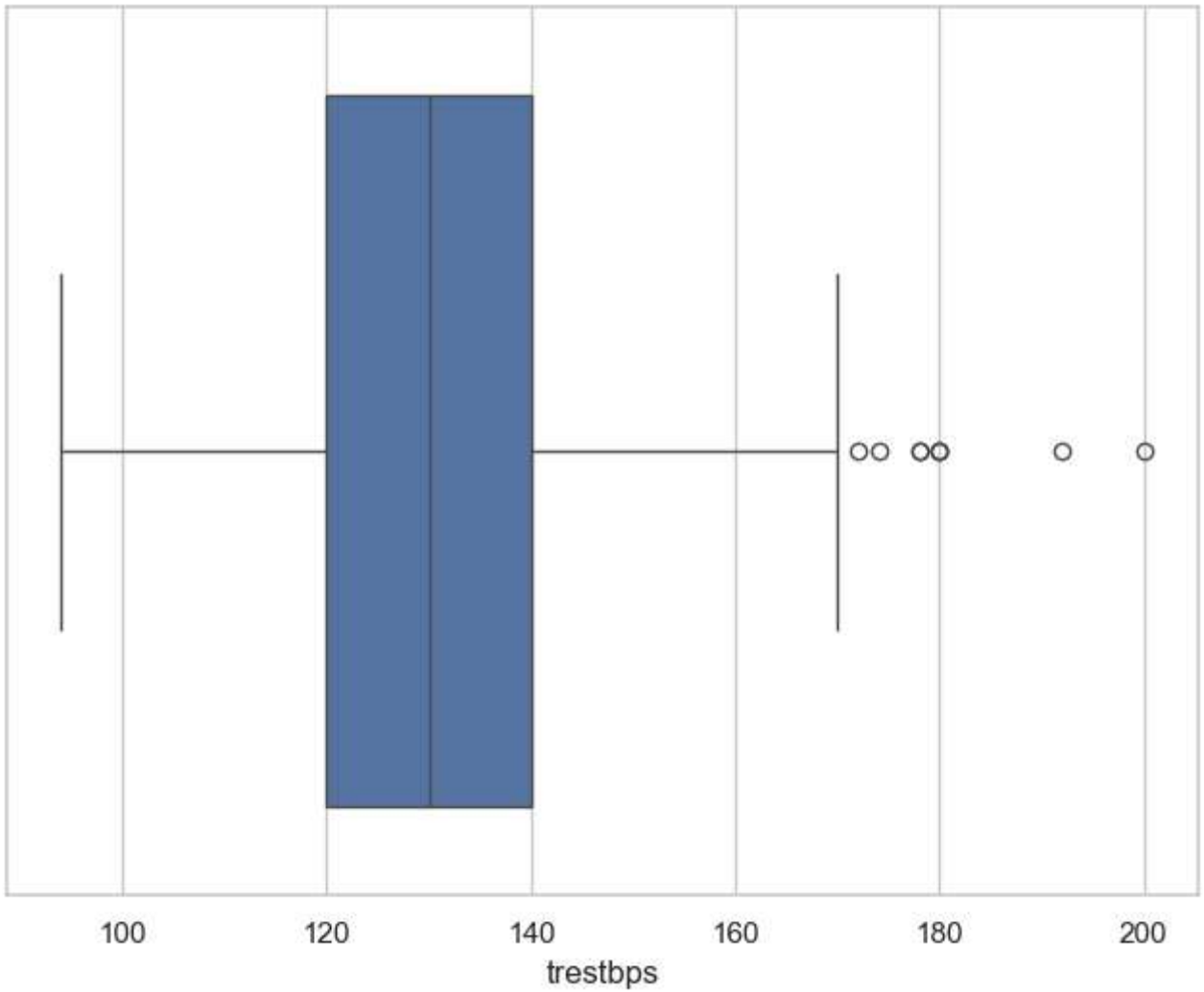
`trestbps` variable

In [73]:
```
df['trestbps'].describe()
```

Out[73]:
```
count    303.000000
mean     131.623762
std       17.538143
min       94.000000
25%      120.000000
50%      130.000000
75%      140.000000
max      200.000000
Name: trestbps, dtype: float64
```

Box-plot of `trestbps` variable

In [74]:
```
f, ax = plt.subplots(figsize=(8, 6))
sns.boxplot(x=df["trestbps"])
plt.show()
```



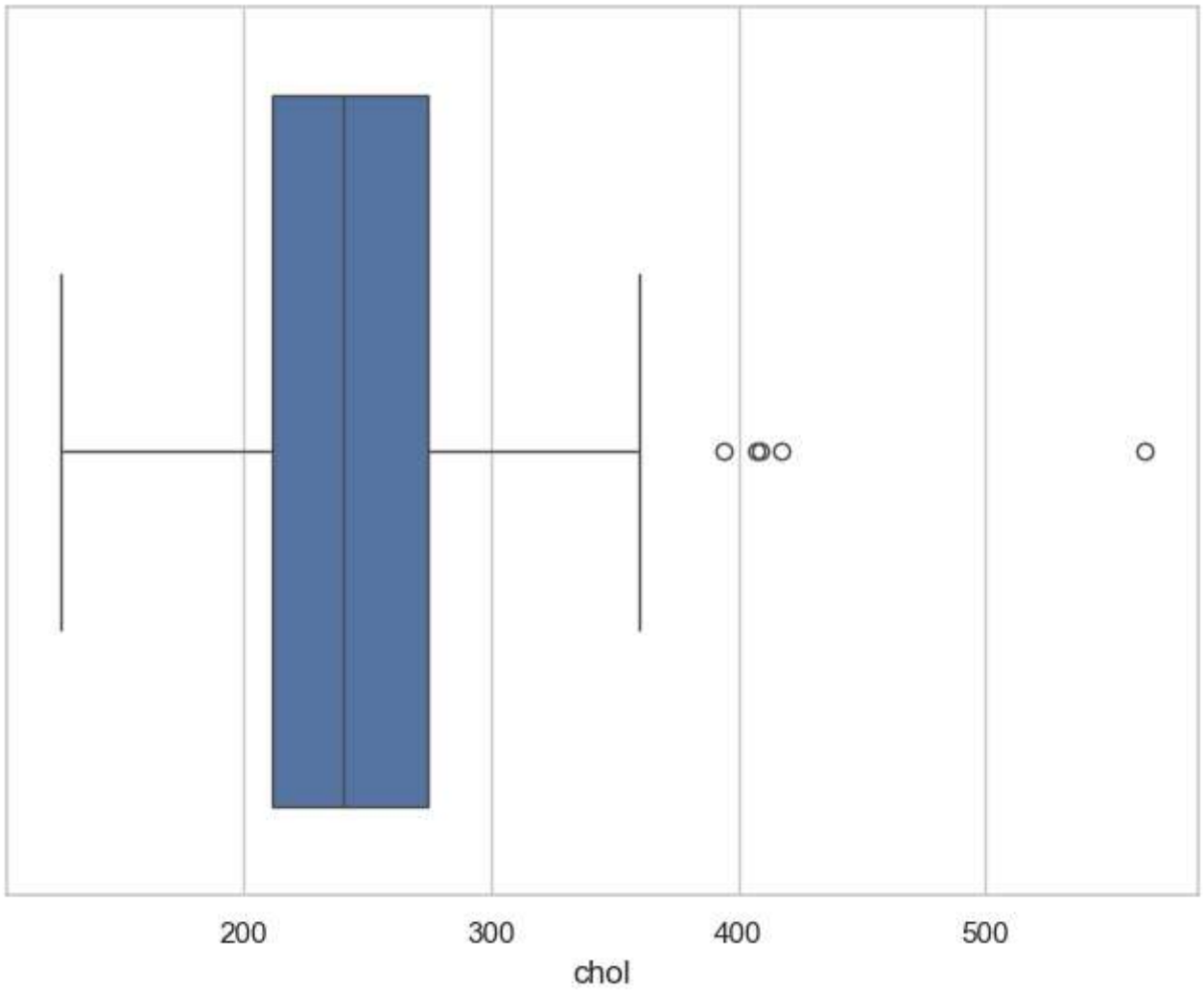
`chol` variable

In [75]:
```
df['chol'].describe()
```

Out[75]:
```
count    303.000000
mean     246.264026
std       51.830751
min      126.000000
25%      211.000000
50%      240.000000
75%      274.500000
max      564.000000
Name: chol, dtype: float64
```

Box-plot of `chol` variable

In [76]:
```
f, ax = plt.subplots(figsize=(8, 6))
sns.boxplot(x=df["chol"])
plt.show()
```



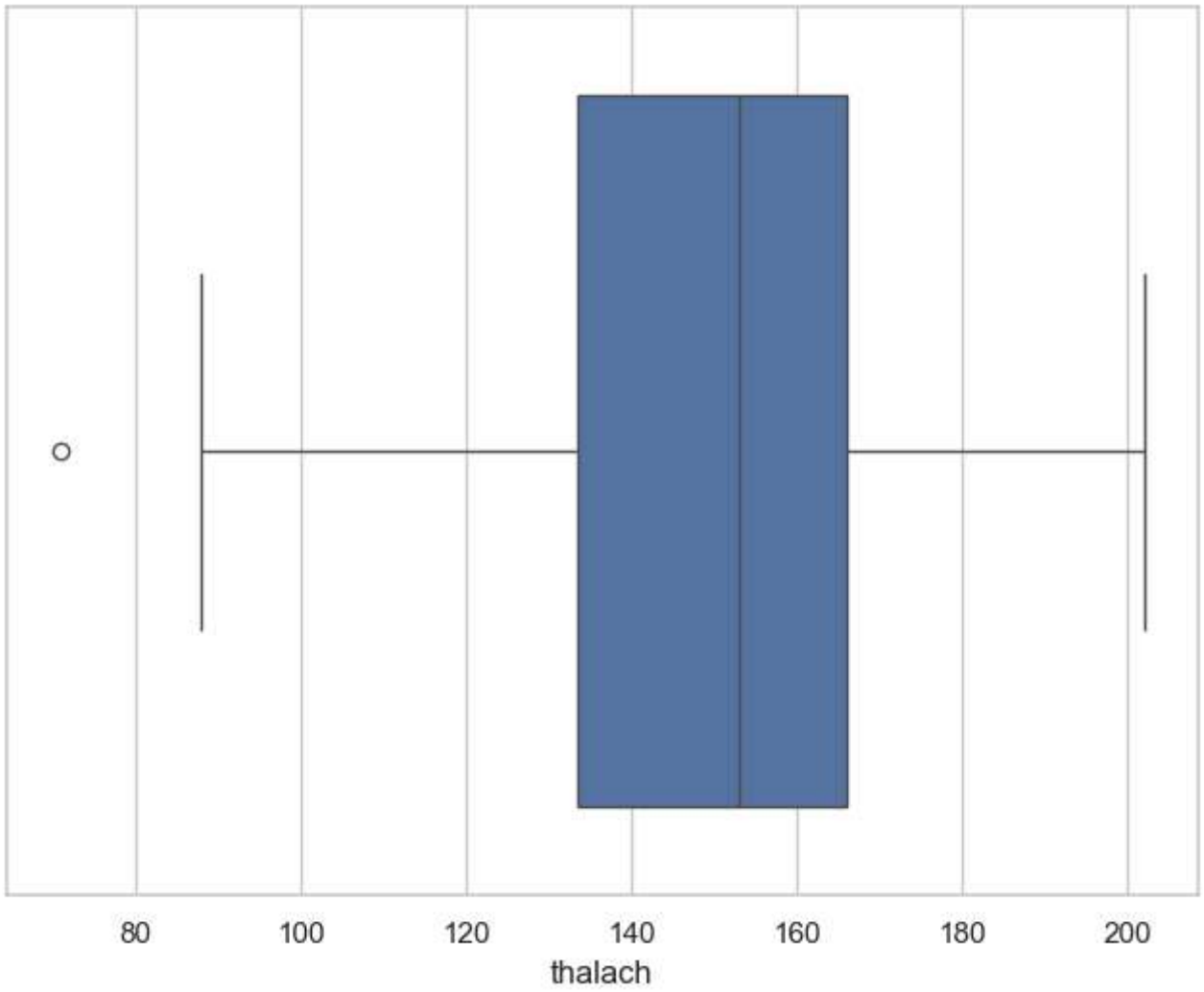
`thalach` variable

In [77]:
```
df['thalach'].describe()
```

Out[77]:
```
count    303.000000
mean     149.646865
std       22.905161
min       71.000000
25%      133.500000
50%      153.000000
75%      166.000000
max      202.000000
Name: thalach, dtype: float64
```

Box-plot of `thalach` variable

In [78]:
```
f, ax = plt.subplots(figsize=(8, 6))
sns.boxplot(x=df["thalach"])
plt.show()
```



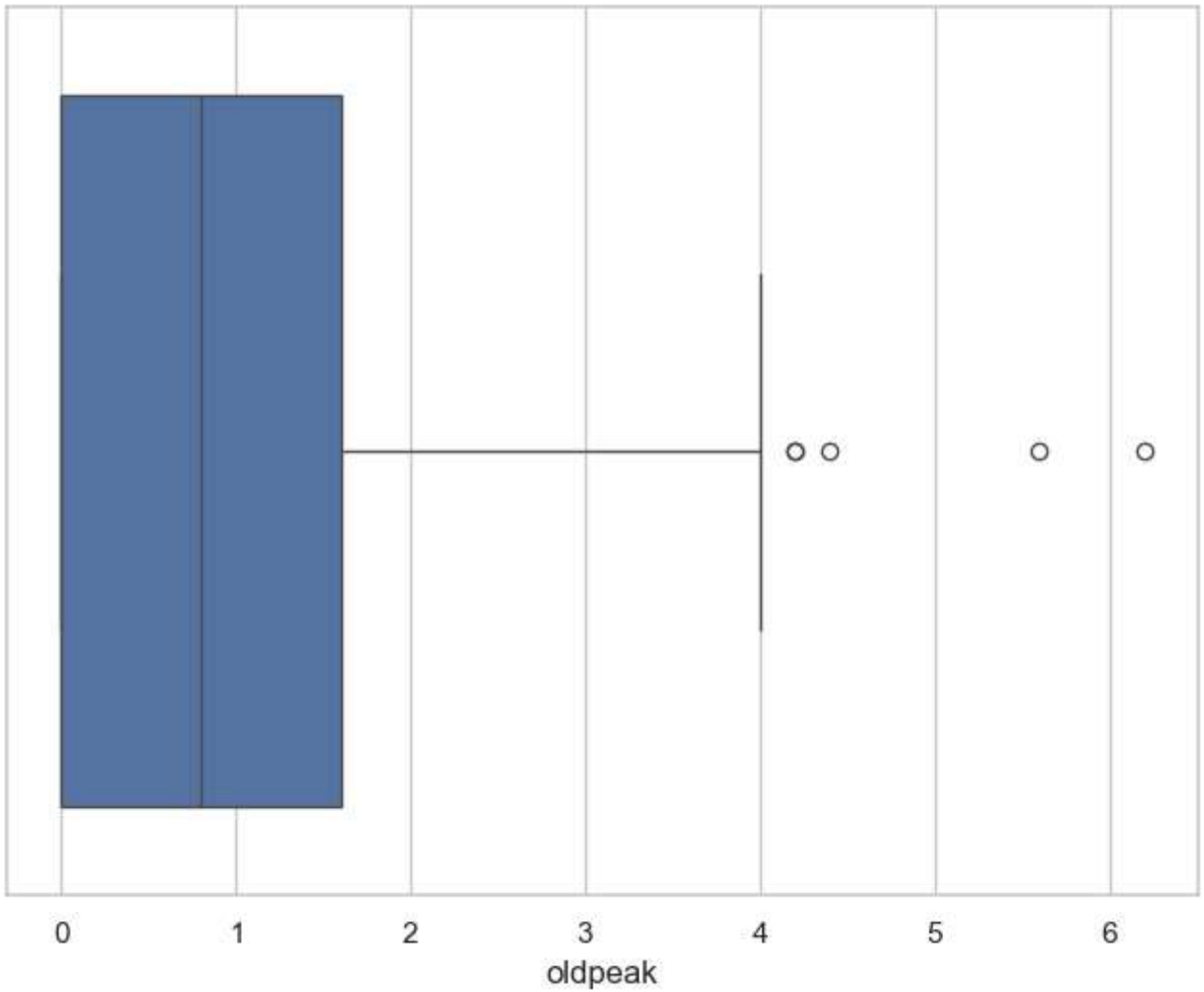
`oldpeak` variable

In [79]:
```
df['oldpeak'].describe()
```

Out[79]:
```
count    303.000000
mean       1.039604
std        1.161075
min        0.000000
25%        0.000000
50%        0.800000
75%        1.600000
max        6.200000
Name: oldpeak, dtype: float64
```

Box-plot of `oldpeak` variable

In [80]:
```
f, ax = plt.subplots(figsize=(8, 6))
sns.boxplot(x=df["oldpeak"])
plt.show()
```



In [ ]: