Influence of salt intake behavior to blood pressure
STATS 506 group project

Xinjun Li

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This is a report generated by jupyter notebook for the group project of STATS 506 in University of Michigan.

Our project aims to answer the following question:

> **Is salt intake associated with blood pressure? If so, to what extent is that relationship mediated or moderated by age or waist size?**

We will use NHANES data in analysis.

Required software and packages to run the code are as follows: * Python3 * os * pandas * statsmodels * patsy * matplotlib

[1]:
```
# Import packages
import os
import pandas as pd
from statsmodels.formula.api import ols
from statsmodels.stats.anova import anova_lm
import patsy
from statsmodels.api import OLS
from statsmodels.stats.mediation import Mediation
import matplotlib.pyplot as plt
```

[2]:
```
# Set working directory
os.chdir('D:/STAT506/Group project/stats506/')

# read data
demo = pd.read_excel("RawData/Demographics_15_16.xlsx")
BMI = pd.read_excel("RawData/Body_measures_2015_16.xlsx")
bp = pd.read_excel('RawData/Blood_Pressure_2015_16.xlsx')
nutr = pd.read_excel("RawData/Dietary_nutrients_firstday_2015_16.xlsx")
```

0.1 Data cleaning

We need first clean the raw data and join different dataset.

[3]:
```
# select useful columns
# ! Note: we need to drop values '9' or '99' which represent "don't know"
demo=demo.set_index('SEQN'
                    ).filter(items=['RIDAGEYR']  # 'RIAGENDR','RIDRETH3'
```

```
                    ).dropna()
# demo[['RIAGENDR','RIDRETH3']]=demo[['RIAGENDR','RIDRETH3']].astype('category')
BMI=BMI.set_index('SEQN'
                  ).filter(items=['BMXWAIST']   # ,'BMXWT','BMXHT'
                  ).dropna()
nutr=nutr.set_index('SEQN'
                    ).filter(items=['DBD100']  #,'DBQ095Z','DRQSPREP'
                    ).dropna(
                    ).query('DBD100 != 9'
                    ).astype('category')

# Calculate mean of blood pressure
bp=bp.set_index('SEQN'
                ).filter(regex='(BPXSY*)|(BPXDI*)')
bp=bp.assign(SY=bp.filter(regex='BPXSY*').mean(axis=1, skipna = True),
             DI=bp.filter(regex='BPXDI*').mean(axis=1, skipna = True)
             ).filter(items=['SY','DI']).dropna()

# Merge all data set
df=bp.join(demo,how='inner').join(BMI,how='inner').join(nutr,how='inner')
```

Take a look at the data we are about to work on.

[4]:
```
# Show data summary of numeric variables
df.describe()
```

[4]:

	SY	DI	RIDAGEYR	BMXWAIST
count	4670.000000	4670.000000	4670.000000	4670.000000
mean	119.510921	66.050393	38.107281	93.630557
std	17.292694	13.378804	21.598139	19.019918
min	74.000000	0.000000	8.000000	46.300000
25%	107.333333	58.666667	18.000000	79.700000
50%	116.666667	66.666667	35.000000	93.000000
75%	128.000000	74.666667	56.000000	105.900000
max	206.666667	124.000000	80.000000	171.600000

[5]:
```
# Show data summary of categorical variables
df.describe(include='category')
```

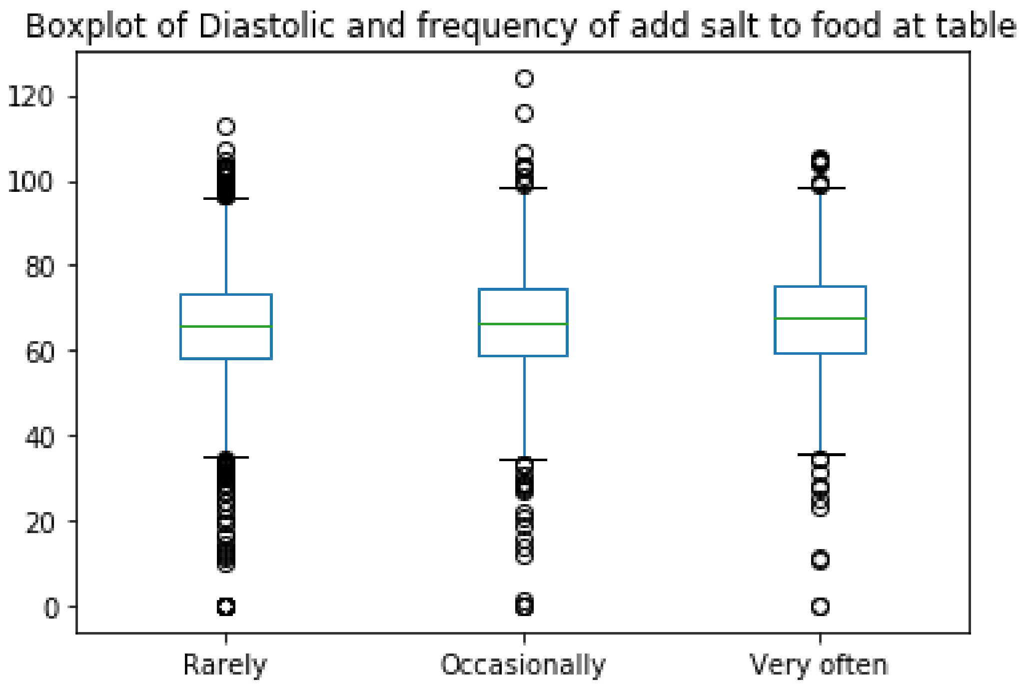
[5]:

	DBD100
count	4670.0
unique	3.0
top	1.0
freq	2444.0

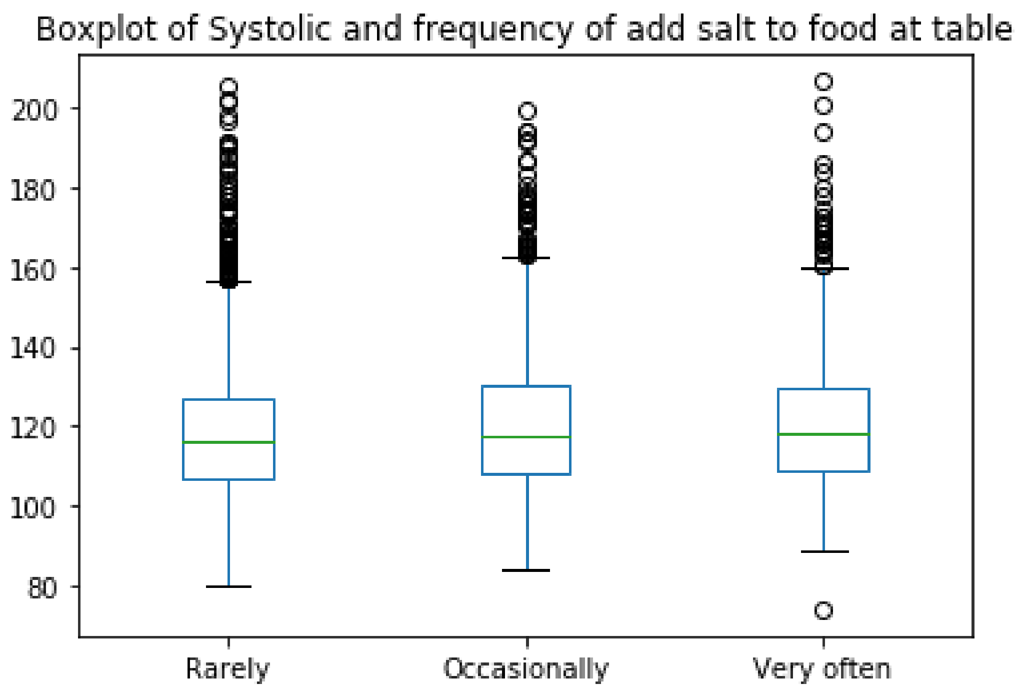
Generate plots show the relationship between salt intake behaviors and blood presure.

[6]:
```
# plot Diastolic and salt intakes
DI_salt=df[['DBD100','DI']
           ].pivot(columns='DBD100', values='DI'
           )
```

```
DI_salt.columns=["Rarely","Occasionally","Very often"]
DI_salt.boxplot(grid=False)
plt.title("Boxplot of Diastolic and frequency of add salt to food at table")
plt.suptitle("")
plt.show()
```



[7]:
```
# plot Systolic and salt intakes
SY_salt=df[['DBD100','SY']
            ].pivot(columns='DBD100', values='SY'
            )
SY_salt.columns=["Rarely","Occasionally","Very often"]
SY_salt.boxplot(grid=False)
plt.title("Boxplot of Systolic and frequency of add salt to food at table")
plt.suptitle("")
plt.show()
```



0.2 Fit OLS

Now fit the ordinary least square to the data. The models used are: `DI ~ DBD100` and `SY ~ DBD100`

0.2.1 Diastolic result

[8]:
```
# fit ols to Diastolic measurements
ols_DI=ols('DI~DBD100',data=df).fit()
# Print the summary
ols_DI.summary()
```

[8]:
```
<class 'statsmodels.iolib.summary.Summary'>
"""
                            OLS Regression Results
==============================================================================
Dep. Variable:                     DI   R-squared:                       0.003
Model:                            OLS   Adj. R-squared:                  0.003
Method:                 Least Squares   F-statistic:                     7.993
Date:                Thu, 05 Dec 2019   Prob (F-statistic):           0.000343
Time:                        12:15:13   Log-Likelihood:                -18730.
No. Observations:                4670   AIC:                         3.747e+04
Df Residuals:                    4667   BIC:                         3.749e+04
Df Model:                           2
Covariance Type:            nonrobust
================================================================================
```

```
=
                    coef    std err          t      P>|t|      [0.025
0.975]
--------------------------------------------------------------------------------
-
Intercept       65.4003      0.270    242.026      0.000      64.871
65.930
DBD100[T.2.0]    0.9326      0.449      2.077      0.038       0.052
1.813
DBD100[T.3.0]    2.0782      0.535      3.886      0.000       1.030
3.127
==============================================================================
Omnibus:                      524.110   Durbin-Watson:                   1.999
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             1560.469
Skew:                          -0.594   Prob(JB):                         0.00
Kurtosis:                       5.570   Cond. No.                         3.29
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
"""
```

[9]:

```python
anova_lm(ols_DI)
```

[9]:

	df	sum_sq	mean_sq	F	PR(>F)
DBD100	2.0	2852.76590	1426.382950	7.992829	0.000343
Residual	4667.0	832862.70838	178.457833	NaN	NaN

0.2.2 Systolic result

[10]:

```python
# fit ols to Systolic measurements
ols_SY=ols('SY~DBD100',data=df).fit()
# Print the summary
ols_SY.summary()
```

[10]:

```
<class 'statsmodels.iolib.summary.Summary'>
"""
                            OLS Regression Results
==============================================================================
Dep. Variable:                     SY   R-squared:                       0.004
Model:                            OLS   Adj. R-squared:                  0.003
Method:                 Least Squares   F-statistic:                     8.841
Date:                Thu, 05 Dec 2019   Prob (F-statistic):           0.000147
Time:                        12:15:13   Log-Likelihood:                -19928.
No. Observations:                4670   AIC:                         3.986e+04
Df Residuals:                    4667   BIC:                         3.988e+04
Df Model:                           2
```

```
Covariance Type:            nonrobust
================================================================================
=
                  coef    std err          t      P>|t|      [0.025
0.975]
--------------------------------------------------------------------------------
-
Intercept       118.5461      0.349    339.471      0.000     117.861
119.231
DBD100[T.2.0]     1.6571      0.580      2.856      0.004       0.520
2.795
DBD100[T.3.0]     2.6321      0.691      3.809      0.000       1.277
3.987
==============================================================================
Omnibus:                      835.290   Durbin-Watson:                   1.966
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             1634.915
Skew:                           1.084   Prob(JB):                         0.00
Kurtosis:                       4.923   Cond. No.                         3.29
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
"""
```

[11]:
```
anova_lm(ols_SY)
```

[11]:

	df	sum_sq	mean_sq	F	PR(>F)
DBD100	2.0	5.269709e+03	2634.854509	8.840718	0.000147
Residual	4667.0	1.390935e+06	298.036262	NaN	NaN

From the above results, we know that both models are significant and every coefficients are significant(at the level of 95%).

0.3 Moderation effect of waist size

First, add two columns recording a standiviation above and below of waist size.

[12]:
```
df['waist_sd'] = df['BMXWAIST'].std()
df['waist_up']=df['BMXWAIST']+df['waist_sd']
df['waist_down']=df['BMXWAIST']-df['waist_sd']
```

0.3.1 Diastolic result

Fit model: `DI ~ DBD100 + BMXWAIST + DBD100 * BMXWAIST`

[13]:
```
moderation_DI = ols('DI ~ DBD100 + BMXWAIST + DBD100 * BMXWAIST', data=df).fit()
moderation_DI.summary()
```

[13]:
```
<class 'statsmodels.iolib.summary.Summary'>
"""
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                     DI   R-squared:                       0.090
Model:                            OLS   Adj. R-squared:                  0.089
Method:                 Least Squares   F-statistic:                     92.35
Date:                Thu, 05 Dec 2019   Prob (F-statistic):           5.66e-93
Time:                        12:15:13   Log-Likelihood:                -18518.
No. Observations:                4670   AIC:                         3.705e+04
Df Residuals:                    4664   BIC:                         3.709e+04
Df Model:                           5
Covariance Type:            nonrobust
================================================================================
==========
                             coef    std err          t      P>|t|      [0.025
0.975]
--------------------------------------------------------------------------------
----------
Intercept                 45.2378      1.273     35.545      0.000      42.743
47.733
DBD100[T.2.0]              2.5683      2.137      1.202      0.229      -1.621
6.757
DBD100[T.3.0]              3.7644      2.720      1.384      0.166      -1.567
9.096
BMXWAIST                   0.2182      0.013     16.179      0.000       0.192
0.245
DBD100[T.2.0]:BMXWAIST    -0.0214      0.022     -0.955      0.339      -0.065
0.023
DBD100[T.3.0]:BMXWAIST    -0.0266      0.028     -0.953      0.341      -0.081
0.028
==============================================================================
Omnibus:                      642.737   Durbin-Watson:                   2.006
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             2183.342
Skew:                          -0.685   Prob(JB):                         0.00
Kurtosis:                       6.057   Cond. No.                     1.62e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.62e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
"""
```

[14]:
```
anova_lm(moderation_DI)
```

[14]:

	df	sum_sq	mean_sq	F	PR(>F)
DBD100	2.0	2852.765900	1426.382950	8.748537	1.613124e-04
BMXWAIST	1.0	72202.692290	72202.692290	442.845941	5.372836e-94

```
DBD100:BMXWAIST     2.0      229.976156    114.988078    0.705265  4.940305e-01
Residual         4664.0  760430.039934    163.042461         NaN           NaN
```

[15]:
```
# one standard deviation above mean
moderation_DI_up = ols('DI ~ DBD100 + waist_up + DBD100 * waist_up', data=df).
 ↪fit()
moderation_DI_up.summary()
```

[15]:
```
<class 'statsmodels.iolib.summary.Summary'>
"""
                            OLS Regression Results
==============================================================================
Dep. Variable:                     DI   R-squared:                       0.090
Model:                            OLS   Adj. R-squared:                  0.089
Method:                 Least Squares   F-statistic:                     92.35
Date:                Thu, 05 Dec 2019   Prob (F-statistic):           5.66e-93
Time:                        12:15:13   Log-Likelihood:                -18518.
No. Observations:                4670   AIC:                         3.705e+04
Df Residuals:                    4664   BIC:                         3.709e+04
Df Model:                           5
Covariance Type:            nonrobust
================================================================================
==========
                           coef    std err          t      P>|t|      [0.025
0.975]
--------------------------------------------------------------------------------
----------
Intercept               41.0870      1.525     26.946      0.000      38.098
44.076
DBD100[T.2.0]            2.9751      2.555      1.164      0.244      -2.035
7.985
DBD100[T.3.0]            4.2712      3.244      1.317      0.188      -2.088
10.630
waist_up                 0.2182      0.013     16.179      0.000       0.192
0.245
DBD100[T.2.0]:waist_up  -0.0214      0.022     -0.955      0.339      -0.065
0.023
DBD100[T.3.0]:waist_up  -0.0266      0.028     -0.953      0.341      -0.081
0.028
==============================================================================
Omnibus:                      642.737   Durbin-Watson:                   2.006
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             2183.342
Skew:                          -0.685   Prob(JB):                         0.00
Kurtosis:                       6.057   Cond. No.                     2.32e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
```

```
specified.
[2] The condition number is large, 2.32e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
"""
```

[16]:
```python
# one standard deviation below mean
moderation_DI_down = ols('DI ~ DBD100 + waist_down + DBD100 * waist_down',␣
↪data=df).fit()
moderation_DI_down.summary()
```

[16]:
```
<class 'statsmodels.iolib.summary.Summary'>
"""
                            OLS Regression Results
==============================================================================
Dep. Variable:                     DI   R-squared:                       0.090
Model:                            OLS   Adj. R-squared:                  0.089
Method:                 Least Squares   F-statistic:                     92.35
Date:                Thu, 05 Dec 2019   Prob (F-statistic):           5.66e-93
Time:                        12:15:14   Log-Likelihood:                -18518.
No. Observations:                4670   AIC:                         3.705e+04
Df Residuals:                    4664   BIC:                         3.709e+04
Df Model:                           5
Covariance Type:            nonrobust
================================================================================
============
                               coef    std err          t      P>|t|      [0.025
0.975]
--------------------------------------------------------------------------------
------------
Intercept                   49.3885      1.023     48.287      0.000      47.383
51.394
DBD100[T.2.0]                2.1615      1.722      1.255      0.209      -1.214
5.537
DBD100[T.3.0]                3.2576      2.200      1.481      0.139      -1.055
7.570
waist_down                   0.2182      0.013     16.179      0.000       0.192
0.245
DBD100[T.2.0]:waist_down    -0.0214      0.022     -0.955      0.339      -0.065
0.023
DBD100[T.3.0]:waist_down    -0.0266      0.028     -0.953      0.341      -0.081
0.028
==============================================================================
Omnibus:                      642.737   Durbin-Watson:                   2.006
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             2183.342
Skew:                          -0.685   Prob(JB):                         0.00
Kurtosis:                       6.057   Cond. No.                     1.06e+03
==============================================================================
```

```
Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.06e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
"""
```

For the models above, coefficients for the interaction terms and salt intake itself are not significant(at level of 95%). There are not moderation effect of waist size on salt intake and diastole.

0.3.2 Systolic result

Fit model: `SY ~ DBD100 + BMXWAIST + DBD100 * BMXWAIST`

[17]:
```python
moderation_SY = ols('SY ~ DBD100 + BMXWAIST + DBD100 * BMXWAIST', data=df).fit()
moderation_SY.summary()
```

[17]:
```
<class 'statsmodels.iolib.summary.Summary'>
"""
                            OLS Regression Results
==============================================================================
Dep. Variable:                     SY   R-squared:                       0.176
Model:                            OLS   Adj. R-squared:                  0.175
Method:                 Least Squares   F-statistic:                     199.6
Date:                Thu, 05 Dec 2019   Prob (F-statistic):          2.71e-193
Time:                        12:15:14   Log-Likelihood:                -19484.
No. Observations:                4670   AIC:                         3.898e+04
Df Residuals:                    4664   BIC:                         3.902e+04
Df Model:                           5
Covariance Type:            nonrobust
================================================================================
==========
                             coef    std err          t      P>|t|      [0.025
0.975]
--------------------------------------------------------------------------------
----------
Intercept                 83.3170      1.565     53.231      0.000      80.248
86.386
DBD100[T.2.0]              1.6470      2.628      0.627      0.531      -3.505
6.799
DBD100[T.3.0]              1.3457      3.345      0.402      0.687      -5.211
7.903
BMXWAIST                   0.3813      0.017     22.986      0.000       0.349
0.414
DBD100[T.2.0]:BMXWAIST    -0.0069      0.028     -0.250      0.802      -0.061
0.047
DBD100[T.3.0]:BMXWAIST    -0.0027      0.034     -0.078      0.938      -0.070
0.065
==============================================================================
```

```
Omnibus:                     1183.493   Durbin-Watson:                   1.972
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             3393.681
Skew:                           1.320   Prob(JB):                         0.00
Kurtosis:                       6.236   Cond. No.                     1.62e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.62e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
"""
```

[18]:

```
anova_lm(moderation_SY)
```

[18]:

```
                     df        sum_sq        mean_sq           F  \
DBD100              2.0  5.269709e+03    2634.854509   10.684907
BMXWAIST            1.0  2.407964e+05  240796.362719  976.481519
DBD100:BMXWAIST     2.0  1.548005e+01       7.740026    0.031387
Residual         4664.0  1.150123e+06     246.595924         NaN

                        PR(>F)
DBD100            2.345321e-05
BMXWAIST         8.385065e-195
DBD100:BMXWAIST   9.691002e-01
Residual                   NaN
```

[19]:

```
# one standard deviation above mean
moderation_SY_up = ols('SY ~ DBD100 + waist_up + DBD100 * waist_up', data=df).
 ↪fit()
moderation_SY_up.summary()
```

[19]:

```
<class 'statsmodels.iolib.summary.Summary'>
"""
                            OLS Regression Results
==============================================================================
Dep. Variable:                     SY   R-squared:                       0.176
Model:                            OLS   Adj. R-squared:                  0.175
Method:                 Least Squares   F-statistic:                     199.6
Date:                Thu, 05 Dec 2019   Prob (F-statistic):          2.71e-193
Time:                        12:15:14   Log-Likelihood:                -19484.
No. Observations:                4670   AIC:                         3.898e+04
Df Residuals:                    4664   BIC:                         3.902e+04
Df Model:                           5
Covariance Type:            nonrobust
================================================================================
==========
                             coef    std err          t      P>|t|      [0.025
0.975]
```

```
------------------------------------------------------------------------------
----------
Intercept                  76.0645      1.875     40.563      0.000      72.388
79.741
DBD100[T.2.0]               1.7782      3.143      0.566      0.572      -4.383
7.939
DBD100[T.3.0]               1.3965      3.989      0.350      0.726      -6.424
9.217
waist_up                    0.3813      0.017     22.986      0.000       0.349
0.414
DBD100[T.2.0]:waist_up     -0.0069      0.028     -0.250      0.802      -0.061
0.047
DBD100[T.3.0]:waist_up     -0.0027      0.034     -0.078      0.938      -0.070
0.065
==============================================================================
Omnibus:                     1183.493   Durbin-Watson:                   1.972
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             3393.681
Skew:                           1.320   Prob(JB):                         0.00
Kurtosis:                       6.236   Cond. No.                     2.32e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 2.32e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
"""
```

[20]:
```
# one standard deviation below mean
moderation_SY_down = ols('SY ~ DBD100 + waist_down + DBD100 * waist_down',
 data=df).fit()
moderation_SY_down.summary()
```

[20]:
```
<class 'statsmodels.iolib.summary.Summary'>
"""
                            OLS Regression Results
==============================================================================
Dep. Variable:                     SY   R-squared:                       0.176
Model:                            OLS   Adj. R-squared:                  0.175
Method:                 Least Squares   F-statistic:                     199.6
Date:                Thu, 05 Dec 2019   Prob (F-statistic):          2.71e-193
Time:                        12:15:14   Log-Likelihood:                -19484.
No. Observations:                4670   AIC:                         3.898e+04
Df Residuals:                    4664   BIC:                         3.902e+04
Df Model:                           5
Covariance Type:            nonrobust
================================================================================
============
```

```
                              coef    std err          t      P>|t|      [0.025
0.975]
--------------------------------------------------------------------------------
------------
Intercept                  90.5694      1.258     72.002      0.000      88.103
93.035
DBD100[T.2.0]               1.5158      2.118      0.716      0.474      -2.636
5.667
DBD100[T.3.0]               1.2949      2.705      0.479      0.632      -4.008
6.598
waist_down                  0.3813      0.017     22.986      0.000       0.349
0.414
DBD100[T.2.0]:waist_down   -0.0069      0.028     -0.250      0.802      -0.061
0.047
DBD100[T.3.0]:waist_down   -0.0027      0.034     -0.078      0.938      -0.070
0.065
==============================================================================
Omnibus:                     1183.493   Durbin-Watson:                   1.972
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             3393.681
Skew:                           1.320   Prob(JB):                         0.00
Kurtosis:                       6.236   Cond. No.                     1.06e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.06e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
"""
```

For the models above, coefficients for the interation terms and salt intake itself are not significant(at level of 95%). There are not moderation effect of waist size on salt intake and diastole.

0.4 Mediation effect of age

Fit model: `RIDAGEYR ~ DBD100` to see if there are relationships between age and salt intake

[21]:
```
# test if there is relationship between age and salt intake.
age_D = ols('RIDAGEYR ~ DBD100', data=df).fit()
age_D.summary()
```

[21]:
```
<class 'statsmodels.iolib.summary.Summary'>
"""
                            OLS Regression Results
==============================================================================
Dep. Variable:               RIDAGEYR   R-squared:                       0.009
Model:                            OLS   Adj. R-squared:                  0.008
Method:                 Least Squares   F-statistic:                     20.96
Date:                Thu, 05 Dec 2019   Prob (F-statistic):           8.67e-10
```

```
Time:                        12:15:14   Log-Likelihood:                -20954.
No. Observations:                4670   AIC:                         4.191e+04
Df Residuals:                    4667   BIC:                         4.193e+04
Df Model:                           2
Covariance Type:            nonrobust
================================================================================
=
                      coef    std err          t      P>|t|      [0.025
0.975]
--------------------------------------------------------------------------------
-
Intercept          36.2901      0.435     83.420      0.000      35.437
37.143
DBD100[T.2.0]       2.9959      0.723      4.145      0.000       1.579
4.413
DBD100[T.3.0]       5.1646      0.861      5.999      0.000       3.477
6.852
==============================================================================
Omnibus:                     1880.486   Durbin-Watson:                   2.043
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              325.994
Skew:                           0.347   Prob(JB):                     1.63e-71
Kurtosis:                       1.908   Cond. No.                         3.29
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
"""
```

The model is significant. There are relationships between age and salt intake behavior.

0.4.1 Diastolic result

Fit model: `DI ~ DBD100 + RIDAGEYR`.

[22]:
```python
mediation_DI = ols('DI ~ DBD100 + RIDAGEYR', data=df).fit()
mediation_DI.summary()
```

[22]:
```
<class 'statsmodels.iolib.summary.Summary'>
"""
                            OLS Regression Results
==============================================================================
Dep. Variable:                     DI   R-squared:                       0.073
Model:                            OLS   Adj. R-squared:                  0.072
Method:                 Least Squares   F-statistic:                     121.6
Date:                Thu, 05 Dec 2019   Prob (F-statistic):           7.67e-76
Time:                        12:15:14   Log-Likelihood:                -18563.
No. Observations:                4670   AIC:                         3.713e+04
Df Residuals:                    4666   BIC:                         3.716e+04
```

```
Df Model:                           3
Covariance Type:            nonrobust
================================================================================
=
                   coef    std err          t      P>|t|      [0.025
0.975]
--------------------------------------------------------------------------------
-
Intercept       59.4642      0.411    144.512      0.000      58.657
60.271
DBD100[T.2.0]    0.4425      0.434      1.020      0.308      -0.408
1.293
DBD100[T.3.0]    1.2334      0.518      2.381      0.017       0.218
2.249
RIDAGEYR         0.1636      0.009     18.646      0.000       0.146
0.181
==============================================================================
Omnibus:                      724.710   Durbin-Watson:                   2.007
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             2672.320
Skew:                          -0.747   Prob(JB):                         0.00
Kurtosis:                       6.391   Cond. No.                         136.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
"""
```

The model is significant. Age might be a mediator between salt intake and diastolic.

[23]:
```
# Create design matrix
DI,model_mat = patsy.dmatrices("DI ~ DBD100 + RIDAGEYR", data=df)
df_med_DI=pd.DataFrame(model_mat).iloc[:,1:]
df_med_DI.columns=['DBD2','DBD3','RIDAGEYR']
df_med_DI['DI']=DI

# origin model and mediator model
med_model_DI=OLS.from_formula('DI ~ RIDAGEYR+DBD2+DBD3', data=df_med_DI)
mediator_DI=OLS.from_formula('RIDAGEYR ~ DBD2+DBD3', data=df_med_DI)

# origin model and mediator model
med_DI = Mediation(med_model_DI,mediator_DI,['DBD2','DBD3'],'RIDAGEYR').fit()
med_DI.summary()
```

[23]:

	Estimate	Lower CI bound	Upper CI bound	P-value
ACME (control)	1.336201	0.894425	1.810091	0.000
ACME (treated)	1.336201	0.894425	1.810091	0.000
ADE (control)	1.692829	0.107259	3.290577	0.038
ADE (treated)	1.692829	0.107259	3.290577	0.038

```
Total effect                3.029030         1.396428         4.608381     0.000
Prop. mediated (control)    0.438871         0.269666         0.920362     0.000
Prop. mediated (treated)    0.438871         0.269666         0.920362     0.000
ACME (average)              1.336201         0.894425         1.810091     0.000
ADE (average)               1.692829         0.107259         3.290577     0.038
Prop. mediated (average)    0.438871         0.269666         0.920362     0.000
```

All the mediation effect(ACME) are significant(at level of 95%). Which means that age is a mediator between salt intake and diastolic.

0.4.2 Systolic result

Fit model: `SY ~ DBD100 + RIDAGEYR`.

[24]:
```python
mediation_SY = ols('SY ~ DBD100 + RIDAGEYR', data=df).fit()
mediation_SY.summary()
```

[24]:
```
<class 'statsmodels.iolib.summary.Summary'>
"""
                            OLS Regression Results
==============================================================================
Dep. Variable:                     SY   R-squared:                       0.326
Model:                            OLS   Adj. R-squared:                  0.326
Method:                 Least Squares   F-statistic:                     753.2
Date:                Thu, 05 Dec 2019   Prob (F-statistic):               0.00
Time:                        12:16:57   Log-Likelihood:                -19015.
No. Observations:                4670   AIC:                         3.804e+04
Df Residuals:                    4666   BIC:                         3.806e+04
Df Model:                           3
Covariance Type:            nonrobust
================================================================================
=
                    coef    std err          t      P>|t|      [0.025
0.975]
--------------------------------------------------------------------------------
-
Intercept       101.9719      0.453    224.951      0.000     101.083
102.861
DBD100[T.2.0]     0.2888      0.478      0.604      0.546      -0.648
1.226
DBD100[T.3.0]     0.2734      0.571      0.479      0.632      -0.845
1.392
RIDAGEYR          0.4567      0.010     47.259      0.000       0.438
0.476
==============================================================================
Omnibus:                      587.593   Durbin-Watson:                   1.956
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             1253.258
Skew:                           0.767   Prob(JB):                    7.22e-273
Kurtosis:                       5.022   Cond. No.                         136.
```

```
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
"""
```

The model is significant. Even thought the coefficients of salt intake is not significant(at level of 95%). Age might be a mediator between salt intake and systolic.

[25]:
```
# Create design matrix
SY,model_mat = patsy.dmatrices("SY ~ DBD100 + RIDAGEYR", data=df)
df_med_SY=pd.DataFrame(model_mat).iloc[:,1:]
df_med_SY.columns=['DBD2','DBD3','RIDAGEYR']
df_med_SY['SY']=SY

# origin model and mediator model
med_model_SY=OLS.from_formula('SY ~ RIDAGEYR+DBD2+DBD3', data=df_med_SY)
mediator_SY=OLS.from_formula('RIDAGEYR ~ DBD2+DBD3', data=df_med_SY)

# origin model and mediator model
med_SY = Mediation(med_model_SY,mediator_SY,['DBD2','DBD3'],'RIDAGEYR').fit()
med_SY.summary()
```

[25]:

	Estimate	Lower CI bound	Upper CI bound	P-value
ACME (control)	3.737113	2.471780	5.024574	0.000
ACME (treated)	3.737113	2.471780	5.024574	0.000
ADE (control)	0.563925	-1.081074	2.157202	0.514
ADE (treated)	0.563925	-1.081074	2.157202	0.514
Total effect	4.301039	2.189444	6.329029	0.000
Prop. mediated (control)	0.870716	0.616533	1.373339	0.000
Prop. mediated (treated)	0.870716	0.616533	1.373339	0.000
ACME (average)	3.737113	2.471780	5.024574	0.000
ADE (average)	0.563925	-1.081074	2.157202	0.514
Prop. mediated (average)	0.870716	0.616533	1.373339	0.000

All the mediation effect(ACME) are significant. Which means that age is a mediator between salt intake and systolic.

0.5 Summary

From the analysis above, we know that the salt intake behavior have significant influence on people's blood pressure (both diastolic and systolic). The influence of salt intake behavior on blood pressure(both diastolic and systolic) is not modirated by waist size. Age is a Mediator between salt intake behavior and blood pressure(both diastolic and systolic).

0.6 Reference

1. https://en.wikipedia.org/wiki/Moderation_(statistics)
2. http://web.pdx.edu/~newsomj/semclass/ho_mediation.pdf

0.7 Aknowledgement

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