

The BMI Health Data

Two sets of measurements are taken on 500 subjects.

- Age
- Body Mass Index (BMI): Weight in kg / squared height in meters
- Percent body fat
- Serum Cholesterol
- Diastolic blood pressure

Measurement Set One is of higher quality. **Measurements in set one should be independent of measurements in set two.**

- Age1 is from birth certificates; Age2 is self-report
- BMI1 is based on height and weight measurements barefoot in a hospital gown in Clinic One. BMI2 is based on height and weight measurements in street clothes, in Clinic Two.
- Fat1 is estimated from immersion; Fat2 is based on tape and calipers
- Cholesterol measurements one and two are based on blood samples taken in Clinics One and Two respectively. They are sent to different labs – likely no difference in quality.
- On Clinic One, blood pressure is measured with an electronic cuff and a digital readout. Clinic Two uses an old-fashioned cuff with manual pump and analogue readout.

Question: Controlling for age and percent body fat, is BMI (still) related to cholesterol level and blood pressure?

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/***** bmi4.sas *****/
options linesize=79 pagesize = 500 noovp formdlim='-';
title 'Body Mass Index (BMI) and Health: Old Fashioned Regression';

data health;
  infile 'bmihealth.data';
  input age1 bmi1 fat1 cholest1 diastol1
        age2 bmi2 fat2 cholest2 diastol2;
  /* fat1 and fat2 are percent body fat */
  age = (age1+age2)/2; bmi = (bmi1+bmi2)/2; fat = (fat1+fat2)/2;
  cholest = (cholest1+cholest2)/2 ; diastol = (diastol1+diastol2)/2;

proc reg;
  title2 'Analyze Average Measures';
  model cholest diastol = age fat bmi;
  MVAvebmi: mtest bmi=0;

proc reg;
  title2 'Analyze Better Measures';
  model cholest1 diastol1 = age1 fat1 bmi1;
  MVbmi1: mtest bmi1=0;

proc reg;
  title2 'Analyze All Measures';
  model cholest1 diastol1 cholest2 diastol2 =
    age1 fat1 bmi1 age2 fat2 bmi2 ;
  MVbmiAll: mtest bmi1=bmi2=0;

```

Body Mass Index (BMI) and Health: Old Fashioned Regression 1
 Analyze Average Measures

The REG Procedure
 Model: MODEL1
 Dependent Variable: cholest

Number of Observations Read 500
 Number of Observations Used 500

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	60127	20042	7.72	<.0001
Error	496	1288325	2597.43027		
Corrected Total	499	1348452			

Root MSE	50.96499	R-Square	0.0446
Dependent Mean	261.63650	Adj R-Sq	0.0388
Coeff Var	19.47931		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > t
Intercept	1	234.61945	20.59784	11.39	<.0001
age	1	0.20780	0.19418	1.07	0.2851
fat	1	1.54921	0.56153	2.76	0.0060
bmi	1	-0.44239	1.02089	-0.43	0.6650

Body Mass Index (BMI) and Health: Old Fashioned Regression 2
 Analyze Average Measures

The REG Procedure
 Model: MODEL1
 Dependent Variable: diastol

Number of Observations Read 500
 Number of Observations Used 500

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	36726	12242	86.69	<.0001
Error	496	70047	141.22393		
Corrected Total	499	106773			

Root MSE 11.88377 R-Square 0.3440
 Dependent Mean 88.56200 Adj R-Sq 0.3400
 Coeff Var 13.41859

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > t
Intercept	1	51.67942	4.80290	10.76	<.0001
age	1	0.10321	0.04528	2.28	0.0231
fat	1	0.81570	0.13094	6.23	<.0001
bmi	1	0.66706	0.23805	2.80	0.0053

Body Mass Index (BMI) and Health: Old Fashioned Regression 3
 Analyze Average Measures

The REG Procedure
 Model: MODEL1
 Multivariate Test: MVAvebmi

Multivariate Statistics and Exact F Statistics

S=1 M=0 N=246.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.98303030	4.27	2	495	0.0145
Pillai's Trace	0.01696970	4.27	2	495	0.0145
Hotelling-Lawley Trace	0.01726264	4.27	2	495	0.0145
Roy's Greatest Root	0.01726264	4.27	2	495	0.0145

Now that you have seen the full output, only parts of the rest will be displayed.

Analyze Better Measures

Dependent Variable: cholest1

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > t
Intercept	1	250.74110	17.03459	14.72	<.0001
age1	1	0.21956	0.18406	1.19	0.2335
fat1	1	1.76562	0.51160	3.45	0.0006
bmi1	1	-1.23252	0.85468	-1.44	0.1499

Dependent Variable: diastoll1

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > t
Intercept	1	49.49578	5.68253	8.71	<.0001
age1	1	0.17898	0.06140	2.91	0.0037
fat1	1	0.63883	0.17066	3.74	0.0002
bmi1	1	0.75534	0.28511	2.65	0.0083

Multivariate Test: MVbmi1

Multivariate Statistics and Exact F Statistics

S=1 M=0 N=246.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.97926655	5.24	2	495	0.0056
Pillai's Trace	0.02073345	5.24	2	495	0.0056
Hotelling-Lawley Trace	0.02117243	5.24	2	495	0.0056
Roy's Greatest Root	0.02117243	5.24	2	495	0.0056

Analyze All Measures

Dependent Variable: cholest1

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > t
Intercept	1	230.97563	22.46294	10.28	<.0001
age1	1	0.10476	0.44373	0.24	0.8135
fat1	1	1.25880	0.67376	1.87	0.0623
bmi1	1	-1.51363	0.98892	-1.53	0.1265
age2	1	0.12428	0.47566	0.26	0.7940
fat2	1	0.27684	0.56978	0.49	0.6273
bmi2	1	1.20047	1.10570	1.09	0.2781

Dependent Variable: diastoll

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > t
Intercept	1	40.82926	7.39162	5.52	<.0001
age1	1	0.15082	0.14601	1.03	0.3021
fat1	1	0.10180	0.22171	0.46	0.6463
bmi1	1	0.75422	0.32541	2.32	0.0209
age2	1	0.00836	0.15652	0.05	0.9574
fat2	1	0.54937	0.18749	2.93	0.0035
bmi2	1	0.36223	0.36384	1.00	0.3199

Dependent Variable: cholest2

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > t
Intercept	1	230.00315	23.05881	9.97	<.0001
age1	1	-0.01509	0.45550	-0.03	0.9736
fat1	1	1.47273	0.69164	2.13	0.0337
bmi1	1	-1.52567	1.01515	-1.50	0.1335
age2	1	0.20833	0.48827	0.43	0.6698
fat2	1	0.08511	0.58489	0.15	0.8844
bmi2	1	1.26057	1.13503	1.11	0.2673

Dependent Variable: diastol2

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > t
Intercept	1	54.27292	4.35870	12.45	<.0001
age1	1	0.00041427	0.08610	0.00	0.9962
fat1	1	0.52929	0.13074	4.05	<.0001
bmi1	1	-0.74801	0.19189	-3.90	0.0001
age2	1	0.04460	0.09230	0.48	0.6291
fat2	1	0.33266	0.11056	3.01	0.0028
bmi2	1	1.38027	0.21455	6.43	<.0001

Multivariate Test: MVbmiAll

Multivariate Statistics and F Approximations

S=2 M=0.5 N=244

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.87023306	8.82	8	980	<.0001
Pillai's Trace	0.13222576	8.69	8	982	<.0001
Hotelling-Lawley Trace	0.14629199	8.95	8	697.68	<.0001
Roy's Greatest Root	0.12339404	15.15	4	491	<.0001

NOTE: F Statistic for Roy's Greatest Root is an upper bound.

NOTE: F Statistic for Wilks' Lambda is exact.