Stat 5100 Handout 2.6.1 – SAS: Inference with Multiple Predictors

Example: (Table 7.1) Study seeks to relate (in females) amount of body fat (Y) to triceps skinfold thickness (X_1), thigh circumference (X_2), and midarm circumference (X_3). Amount of body fat is expensive to measure, requiring immersion of person in water. This expense motivates the desire for a predictive model based on these inexpensive predictors.

Q1: Do thigh and midarm both have no effect on body fat when triceps is in the model?

Q2: Do the relationships among the predictors cause any problems in the fitted model?

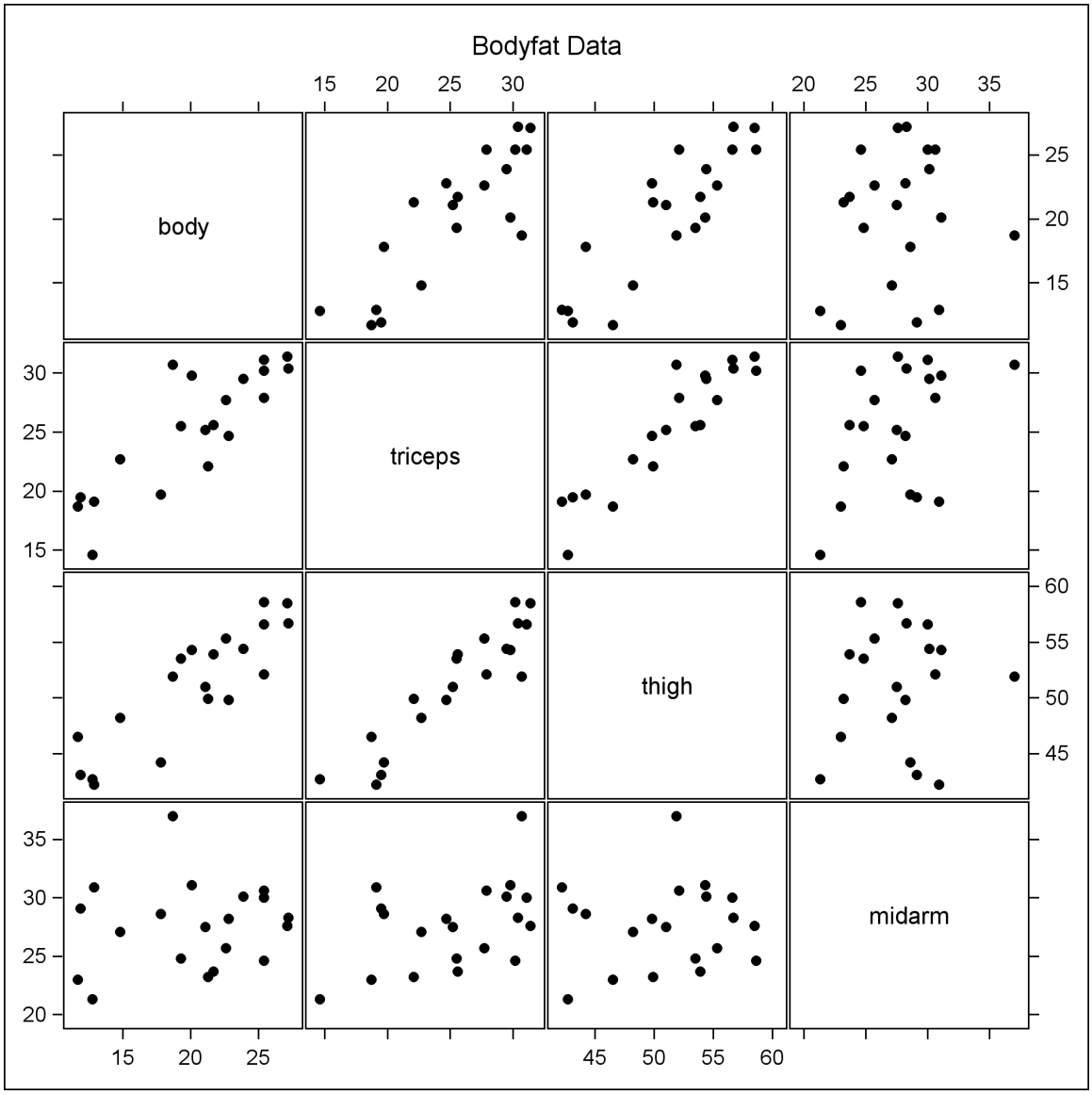
```
/* Input data */
data bodyfat;
   input triceps thigh midarm body @@; cards;
  19.5  43.1  29.1  11.9      24.7  49.8  28.2  22.8
  30.7  51.9  37.0  18.7      29.8  54.3  31.1  20.1
  19.1  42.2  30.9  12.9      25.6  53.9  23.7  21.7
  31.4  58.5  27.6  27.1      27.9  52.1  30.6  25.4
  22.1  49.9  23.2  21.3      25.5  53.5  24.8  19.3
  31.1  56.6  30.0  25.4      30.4  56.7  28.3  27.2
  18.7  46.5  23.0  11.7      19.7  44.2  28.6  17.8
  14.6  42.7  21.3  12.8      29.5  54.4  30.1  23.9
  27.7  55.3  25.7  22.6      30.2  58.6  24.6  25.4
  22.7  48.2  27.1  14.8      25.2  51.0  27.5  21.1
;
run;

proc corr data=bodyfat;
  var body triceps
      thigh midarm;
  title1 'Correlation
matrix';
run;
```

Pearson Correlation Coefficients, N = 20
Prob > |r| under H0: Rho=0

	body	triceps	thigh	midarm
body	1.00000	0.84327 <.0001	0.87809 <.0001	0.14244 0.5491
triceps	0.84327 <.0001	1.00000	0.92384 <.0001	0.45778 0.0424
thigh	0.87809 <.0001	0.92384 <.0001	1.00000	0.08467 0.7227
midarm	0.14244 0.5491	0.45778 0.0424	0.08467 0.7227	1.00000

```
proc sgscatter data=bodyfat;
  matrix  body triceps thigh midarm/
     markerattrs=(symbol=CIRCLEFILLED size=2pt);
  title1 'Bodyfat Data';
run;
```



```
/* Q1: Test whether thigh and midarm BOTH have
   no effect on body when triceps is in the model */

proc reg data=bodyfat;
  model body = triceps thigh midarm;
  title1 'Bodyfat Regression';
  title2 '(full model)';
run;
```

Bodyfat Regression
(full model)

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	3	396.98461	132.32820	21.52	<.0001
Error	16	98.40489	6.15031		
Corrected Total	19	495.38950			

```
proc reg data=bodyfat;
  model body = triceps;
  title1 'Bodyfat Regression';
  title2 '(reduced model)';
run;
```

Bodyfat Regression
(reduced model)

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1	352.26980	352.26980	44.30	<.0001
Error	18	143.11970	7.95109		
Corrected Total	19	495.38950			

```
data temp;
  F = ( (143.11970-98.40489)/2 ) / ( 6.15031 );
  p = 1-probf(F,2,16);
proc print data=temp;
  title1 'Subset F-test, by hand';
run;
```

Subset F-test, by hand

Obs	F	p
1	3.63517	0.049950

```
/* Do this subset F-test, automatically.
   Also look at related quantities:
   See all sequential sums of squares and
   coefficients of partial determination */
proc reg data=bodyfat;
  model body = triceps thigh midarm / ss1 pcorr1;
  subsetcheck: test thigh=midarm=0;
  title1 'Subset F-test, automatically';
run;
```

Subset F-test, automatically

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Type I SS	Squared Partial Corr Type I
Intercept	1	117.08469	99.78240	1.17	0.2578	8156.76050	.
triceps	1	4.33409	3.01551	1.44	0.1699	352.26980	0.71110
thigh	1	-2.85685	2.58202	-1.11	0.2849	33.16891	0.23176
midarm	1	-2.18606	1.59550	-1.37	0.1896	11.54590	0.10501

Test subsetcheck Results for Dependent Variable body

Source	DF	Mean Square	F Value	Pr > F
Numerator	2	22.35741	3.64	0.0500
Denominator	16	6.15031		

```
/* Q2: Investigate effect of relationships among
predictors. */


/* Standardizing all variables */
proc reg data=bodyfat;
  model body = triceps thigh midarm / stb;
  title1 'Standardized regression coefficients';
  title2 '(note extra column in output)';
run;
```

Standardized regression coefficients
(note extra column in output)

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Standardized Estimate
Intercept	1	117.08469	99.78240	1.17	0.2578	0
triceps	1	4.33409	3.01551	1.44	0.1699	4.26370
thigh	1	-2.85685	2.58202	-1.11	0.2849	-2.92870
midarm	1	-2.18606	1.59550	-1.37	0.1896	-1.56142

```
/* Test for multicollinearity */
proc reg data=bodyfat;
  model body = triceps thigh midarm / vif collin;
  title1 'Test for multicollinearity';
run;
```

Test for multicollinearity

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	396.98461	132.32820	21.52	<.0001
Error	16	98.40489	6.15031		
Corrected Total	19	495.38950			

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Variance Inflation
Intercept	**1**	117.08469	99.78240	1.17	0.2578	0
triceps	**1**	4.33409	3.01551	1.44	0.1699	708.84291
thigh	**1**	-2.85685	2.58202	-1.11	0.2849	564.34339
midarm	**1**	-2.18606	1.59550	-1.37	0.1896	104.60601

Collinearity Diagnostics

Number	Eigenvalue	Condition Index	Proportion of Variation			
			Intercept	triceps	thigh	midarm
1	3.96796	1.00000	0.00000195	0.00000320	0.00000110	0.00000980
2	0.02052	13.90482	0.00037152	0.00132	0.00003262	0.00139
3	0.01151	18.56570	0.00059915	0.00021875	0.00032550	0.00693
4	0.00000865	677.37207	0.99903	0.99846	0.99964	0.99167