One-Way Univariate
Analysis of Covariance (ANCOVA) by Regression

1. Regression: Do your sub-groups have different slopes?

Descriptive Statistics

	Mean	Std. Deviation	N
Y	33.80	6.795	15
X	25.00	5.071	15
T1	.00	.845	15
T2	.00	.845	15
CT1	-.7333	20.88221	15
CT2	.3333	22.34044	15

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.970[a]	.940	.924	1.873	.940	57.781	3	11	.000
2	.975[b]	.951	.924	1.871	.011	1.007	2	9	.403

a. Predictors: (Constant), T2, X, T1

b. Predictors: (Constant), T2, X, T1, CT2, CT1

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	607.829	3	202.610	57.781	.000[a]
	Residual	38.571	11	3.506		
	Total	646.400	14			
2	Regression	614.879	5	122.976	35.113	.000[b]
	Residual	31.521	9	3.502		
	Total	646.400	14			

a. Predictors: (Constant), T2, X, T1

b. Predictors: (Constant), T2, X, T1, CT2, CT1

c. Dependent Variable: Y

Model of choice because the Full-Model is not adequate (i.e. the interaction effects have no impact)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	11.336	2.610		4.344	.001	5.592	17.080
	X	.899	.103	.671	8.759	.000	.673	1.124
	T1	6.017	.708	.748	8.496	.000	4.459	7.576
	T2	.942	.699	.117	1.348	.205	-.596	2.480
2	(Constant)	10.426	2.795		3.731	.005	4.104	16.748
	X	.939	.113	.701	8.332	.000	.684	1.194
	T1	2.457	4.417	.306	.556	.592	-7.535	12.449
	T2	-.595	3.738	-.074	-.159	.877	-9.052	7.861
	CT1	.153	.184	.469	.827	.430	-.265	.570
	CT2	.053	.146	.173	.361	.727	-.277	.382

a. Dependent Variable: Y

2. Regression: Test if the covariate (pre-test; X) predicts "Y" over and above treatments

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.724[a]	.524	.445	5.063	.524	6.609	2	12	.012
2	.970[b]	.940	.924	1.873	.416	76.723	1	11	.000

a. Predictors: (Constant), T2, T1

b. Predictors: (Constant), T2, T1, X

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	338.800	2	169.400	6.609	.012[a]
	Residual	307.600	12	25.633		
	Total	646.400	14			
2	Regression	607.829	3	202.610	57.781	.000[b]
	Residual	38.571	11	3.506		
	Total	646.400	14			

a. Predictors: (Constant), T2, T1

b. Predictors: (Constant), T2, T1, X

c. Dependent Variable: Y

Model of choice because the Full-Model is adequate (i.e. the covariate has an impact ~ change on R-squared)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	33.800	1.307		25.856	.000
	T1	4.400	1.849	.547	2.380	.035
	T2	2.200	1.849	.274	1.190	.257
2	(Constant)	11.336	2.610		4.344	.001
	T1	6.017	.708	.748	8.496	.000
	T2	.942	.699	.117	1.348	.205
	X	.899	.103	.671	8.759	.000

a. Dependent Variable: Y

3. Regression: To test is the treatments predict "Y" over and above the covariate (X)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.543[a]	.295	.241	5.921	.295	5.439	1	13	.036
2	.970[b]	.940	.924	1.873	.645	59.483	2	11	.000

a. Predictors: (Constant), X

b. Predictors: (Constant), X, T2, T1

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	190.678	1	190.678	5.439	.036[a]
	Residual	455.722	13	35.056		
	Total	646.400	14			
2	Regression	607.829	3	202.610	57.781	.000[b]
	Residual	38.571	11	3.506		
	Total	646.400	14			

a. Predictors: (Constant), X

b. Predictors: (Constant), X, T2, T1

c. Dependent Variable: Y

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	15.606	7.950		1.963	.071
	X	.728	.312	.543	2.332	.036
2	(Constant)	11.336	2.610		4.344	.001
	X	.899	.103	.671	8.759	.000
	T1	6.017	.708	.748	8.496	.000
	T2	.942	.699	.117	1.348	.205

a. Dependent Variable: Y

Model of choice because the Full-Model is adequate (i.e. the treatments have an impact ~ change on R-squared) suggesting that the different groups have different means.

One-Way Univariate Analysis of Covariance

(You will not be able to use SPSS to verify your computations. Double check your own equations)

Between-Subjects Factors

		N
T1	-1	5
	0	5
	1	5

1. Grand Mean

Dependent Variable:Y

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
33.800[a]	.483	32.736	34.864

a. Covariates appearing in the model are evaluated at the following values: X = 25.00.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	11.336	2.610		4.344	.001	5.592	17.080
	X	.899	.103	.671	8.759	.000	.673	1.124
	T1	6.017	.708	.748	8.496	.000	4.459	7.576
	T2	.942	.699	.117	1.348	.205	-.596	2.480

a. Dependent Variable: Y

Your computation of the Grand Mean:

$$\begin{aligned}\bar{\bar{Y}} &= Intercept + \beta_1 \times X + \beta_2 \times T_1 + \beta_3 \times T_2 \\ &= 11.336 + .899 \times 25.0 + 6.017 \times 0 + .942 \times 0 \\ &= 11.336 + 22.475 + 0 + 0 = 33.811\end{aligned}$$

Your computations for the adjusted group means:

Estimates

Dependent Variable:Y

T1	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
-1	26.841[a]	.838	24.995	28.686
0	34.742[a]	.850	32.872	36.612
1	39.817[a]	.858	37.930	41.705

a. Covariates appearing in the model are evaluated at the following values: X = 25.00.

$$\bar{Y}_1 = 11.336 + .899 \times 25.0 + 6.017 \times 1 + .942 \times 0 = 33.811 + 6.017 = 39.828$$

$$\bar{Y}_0 = 11.336 + .899 \times 25.0 + 6.017 \times 0 + .942 \times 1 = 33.811 + .942 = 34.753$$

$$\bar{Y}_{-1} = 11.336 + .899 \times 25.0 + 6.017 \times (-1) + .942 \times (-1) = 33.811 - 6.017 - .942 = 26.852$$

Your computations for multiple group comparisons:

$$F_{(1,N-\#groups-1)} = \frac{\left(\overline{Y}_1 - \overline{Y}_0\right)^2}{MS_{\text{Res Error}} \times \left[\left(\frac{1}{n_1} + \frac{1}{n_2}\right) + \frac{\left(\overline{X}_1 - \overline{X}_0\right)^2}{SS_{\text{Res Error}\,(C=T_j)}}\right]}$$

1. Regression: Do your sub-groups have different slopes?

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	607.829	3	202.610	57.781	.000[a]
	Residual	38.571	11	3.506		
	Total	646.400	14			

a. Predictors: (Constant), T2, X, T1

c. Dependent Variable: Y

4. Regression: Regressing the covariate (X) unto the indicator variables

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.273[a]	.074	-.080	5.269

a. Predictors: (Constant), T2, T1

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	26.800	2	13.400	.483	.629[a]
	Residual	333.200	12	27.767		
	Total	360.000	14			

a. Predictors: (Constant), T2, T1

b. Dependent Variable: X

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	25.000	1.361		18.375	.000
	T1	-1.800	1.924	-.300	-.935	.368
	T2	1.400	1.924	.233	.728	.481

a. Dependent Variable: X

You can get the group specific covariate means by going to Analyze → Compare Means → Means…

5. Means for the covariats for each treatment group

Report

X

T1	Mean	N	Std. Deviation
-1	25.40	5	5.941
0	26.40	5	5.857
1	23.20	5	3.701
Total	25.00	15	5.071

Computations for comparing the adjusted means for group 1 (T1=1) and (T1=0):

$$F_{(1,N-\#groups-1)} = \frac{(39.828-34.753)^2}{3.506\times\left[\left(\frac{1}{5}+\frac{1}{5}\right)+\frac{(23.20-26.40)^2}{333.20}\right]}$$

$$= \frac{(5.075)^2}{3.506\times\left[(.2+.2)+\frac{(-3.20)^2}{333.20}\right]}$$

$$= \frac{25.7556}{3.506\times\left[(.4)+\frac{10.24}{333.20}\right]} = \frac{25.7556}{3.506\times[.4+.03073]} = \frac{25.7556}{3.506\times.43073} = \frac{25.7556}{1.5101} = 17.0550$$

Get the F critical value from the Excel function "=finv(probability, df1, df2)"

$$F_{CRIT} = F_{(\alpha,\ 1,N-\#groups-1)} = F_{(.05,\ 1,15-3-1)} = F_{(1,11)} = 4.8443$$

You can get your F value significance from the Excel function "=fdist(value, df1, df2)"

$$p-value_F = .0017$$

You would compute three separate F-values comparing all of your adjusted group means between each other (1 vs. 0, which we did, then 1 vs. -1, and 0 vs. -1).