Factorial ANOVA
(between groups)
Two-way ANOVA

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Tests of group differences

1 independent variable (2 levels) – 1 dependent → Independent t-test

1 independent variable (3+ levels) – 1 dependent→ one-way ANOVA

2 independent variables – 1 dependent → two-way ANOVA

When?
To analyze a situation in which there are two or more independent variables

Specific name
The specific names (e.g., two- way Anova) reflect the experimental design

1 independent variable (2 levels) – dependent → t-test

Examine differences in height between males and females

Gender (independent – 2 levels)

Height (dependent)

We conducted independent t-test to examine differences in height between males and females. The results showed…

1 independent (>2 επίπεδα) – 1 dependent → one-way ANOVA

Differences in height between classes in secondary school

Class (independent – 3 levels: 1st, 2nd, 3rd grade)

Height (dependent)

We conducted One-way ANOVA to examine differences in height between 1st, 2nd and 3rd grade in secondary school. The results showed…

2 independent variables – 1 dependent → two-way ANOVA

Differences in height between grades and gender

Grades (independent – 3 levels: 1st, 2nd, & 3rd grade)

Gender (independent- 2 levels)

Height (dependent)

We conducted two-way ANOVA to examine differences in height between males and females in the 1st, 2nd and the 3rd grade. The results showed…

Example – 2(levels of the first factor) x2(levels of the second factor)ANOVA

To determine the effectiveness of different methods of training (PNF and passive flexibility) in flexibility between males and females

Two-factor designs examine the seperate and combined effects of two independent variables upon a dependent variable

Questions of the two-factor design

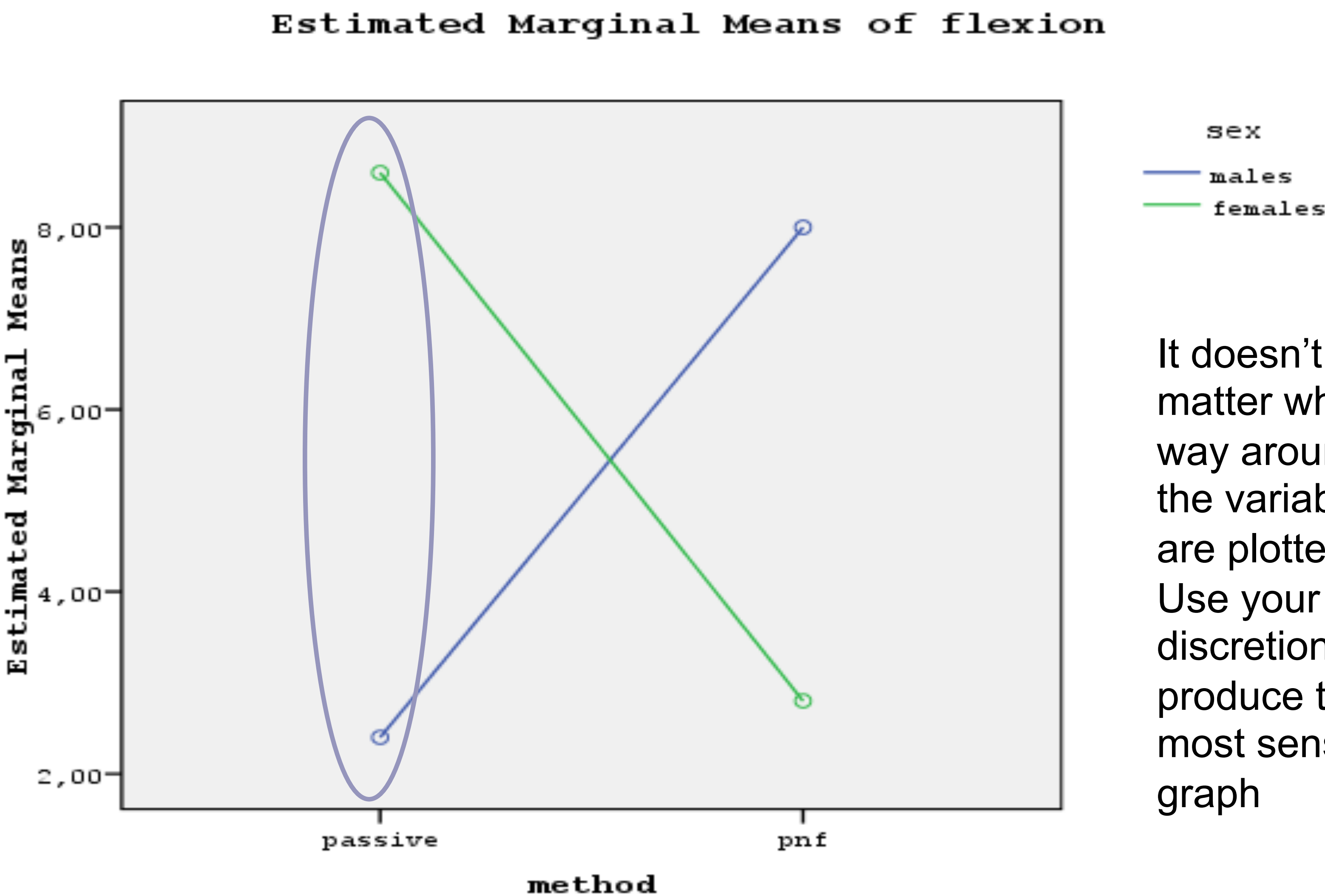
- **Main effect for gender: Do men increase in flexibility more than women as a result of flexibility training?**
- **Main effect for training method: Is PNF more effective than passive training in increasing flexibility?**
- **Interaction between Gender and Training method: Does the effectiveness of PNF and passive training depend upon whether the stretching training is being followed by men or women?**

Hypotheses On two- way Anova (3 hypotheses) | One-way (1 hypothesis)

- **Main effect for gender**:
  Ho = Mmales = Mfemales
- **Main effect for method**:
  Ho = Mpnf = Mpassive
- **Interaction sex by method**:

  Ho = Mpnf + Mpassive are the same for males and females

Graphing interactions – Click on plots

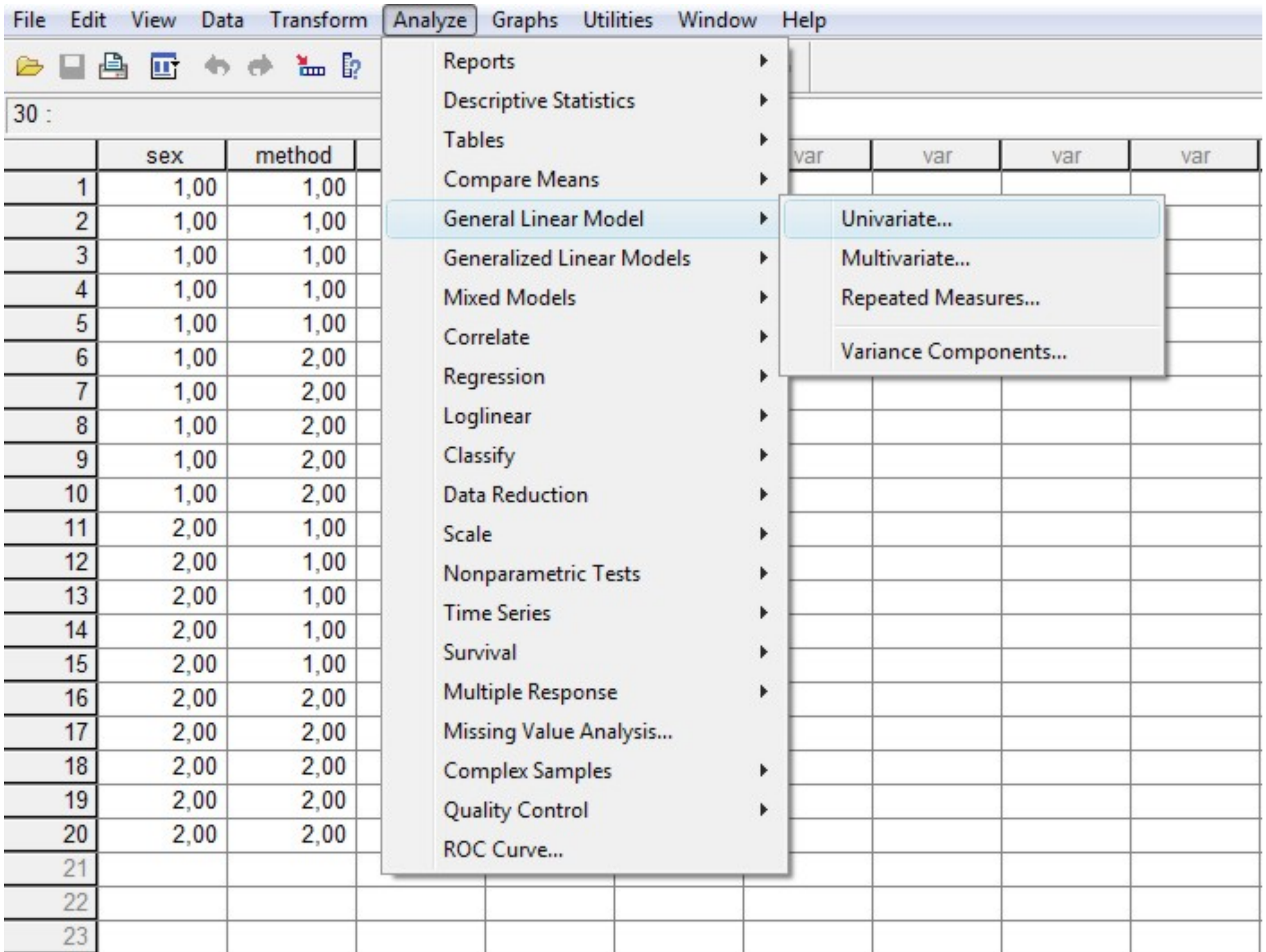


It doesn't matter which way around the variables are plotted. Use your discretion to produce the most sensible graph

Assumptions

- The scores of the dependent variable should come from a population which is normally distributed (i.e., normality assumption). *Use* **Histogram with normal curve in the Descriptive Statistics/Frequencies or with *Frequencies* option** *check skewness and kurtosis values (if they are above 1.96 -standard errors, the data are probably not normally distributed)*

- The two samples should come from populations which have approximately the same variance (i.e., homogeneity of variance assumption). *Use* **Levene test to test this assumption**. *(not significant!!!)*


File Edit View Data Transform Analyze Graphs Utilities Window Help
30 :
sex method var var var var
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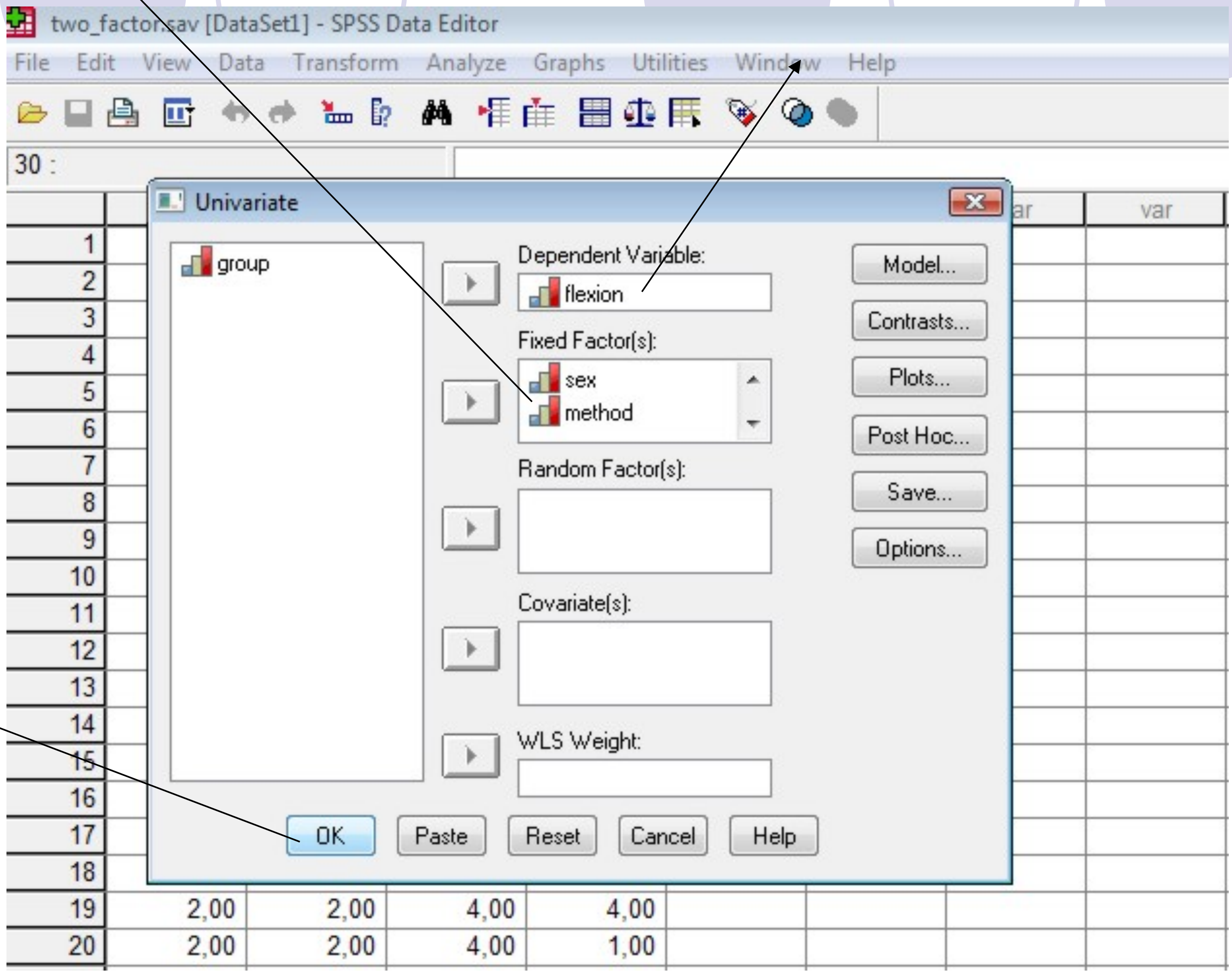
23
Reports
Descriptive Statistics
Tables
Compare Means
General Linear Model
Generalized Linear Models
Mixed Models
Correlate
Regression
Loglinear
Classify
Data Reduction
Scale
Nonparametric Tests
Time Series
Survival
Multiple Response
Missing Value Analysis...
Complex Samples
Quality Control
ROC Curve...
Univariate...
Multivariate...
Repeated Measures...
Variance Components...

Independent, e.g., Sex, method

Dependent, e.g., flexion



Click OK

Note: When interaction F is significant, the main effect must be interpreted with caution- or not interpreted at all. If main effects are significant and interaction effect, we can pay attention only to the cell means and not to the main effects means.

Univariate Analysis of Variance

[DataSet1] C:\Users\Nikos\Desktop\two_factor.sav

Between-Subjects Factors

		Value Label	N
sex	1,00	males	10
	2,00	females	10
method	1,00	passive	10
	2,00	pnf	10

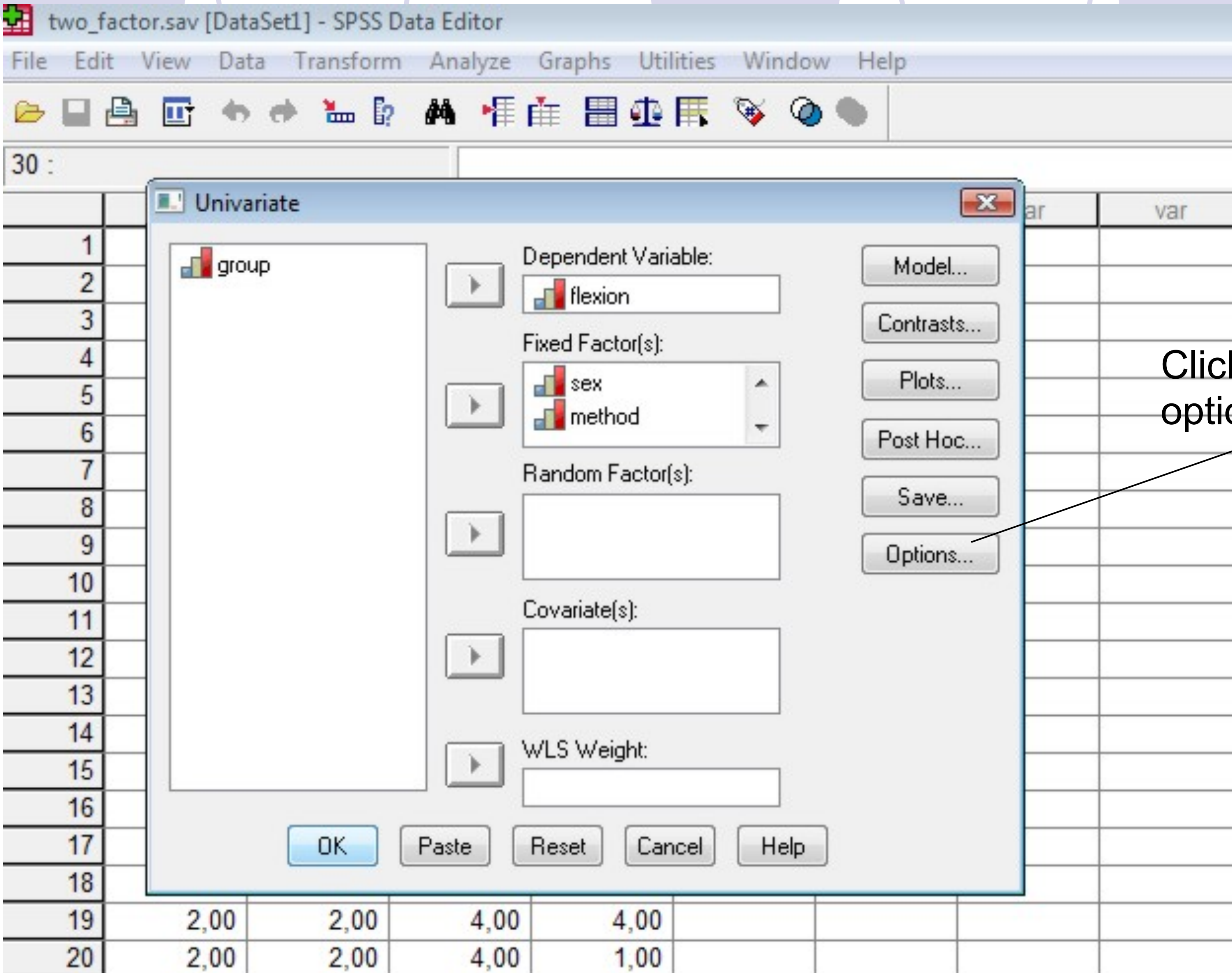
Tests of Between-Subjects Effects

Dependent Variable: flexion

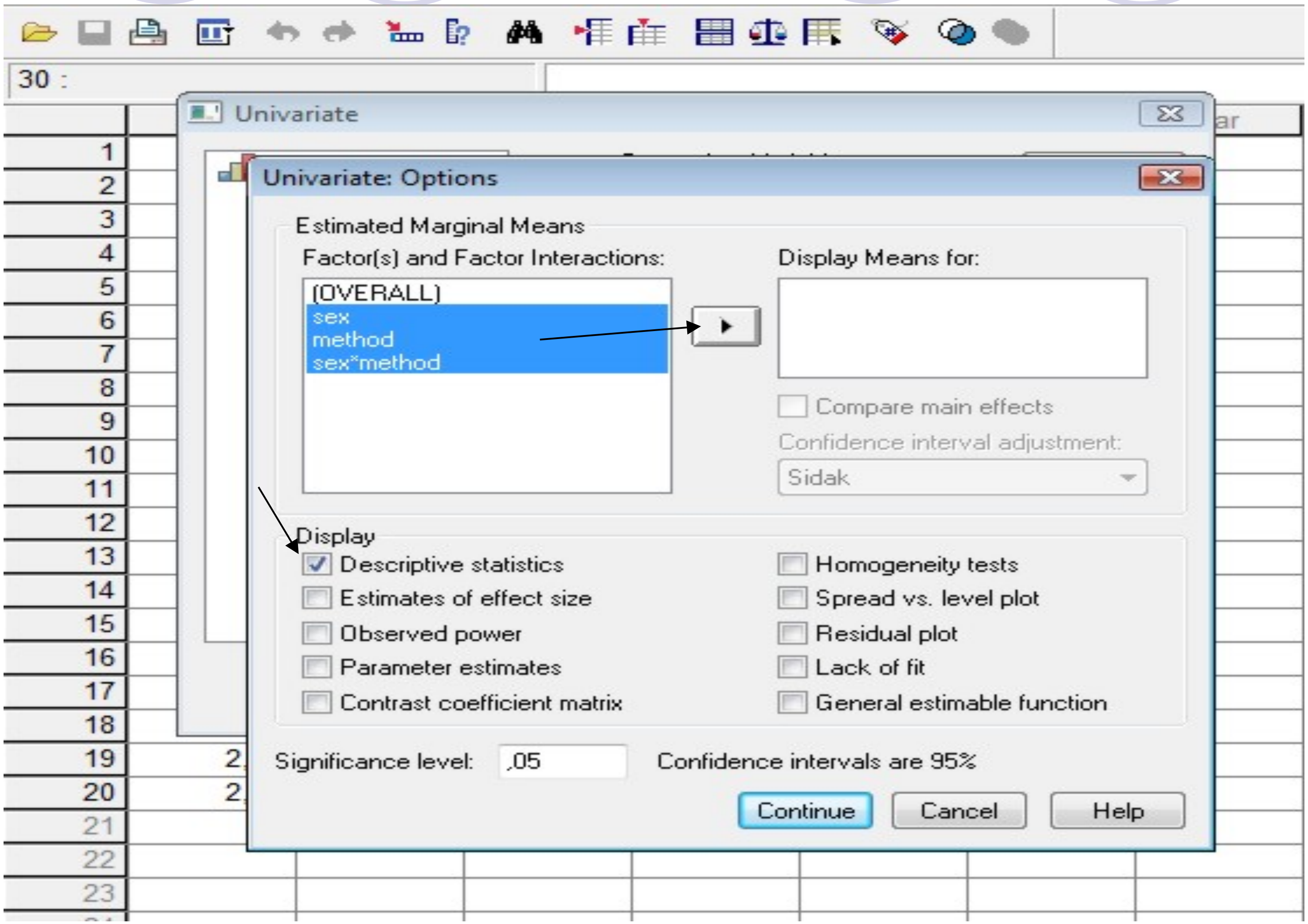
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	163,750[a]	3	54,583	32,108	,000
Intercept	594,050	1	594,050	349,441	,000
sex	1,250	1	1,250	,735	,404
method	,050	1	,050	,029	,866
sex * method	162,450	1	162,450	95,559	,000
Error	27,200	16	1,700		
Total	785,000	20			
Corrected Total	190,950	19			

a. R Squared = ,858 (Adjusted R Squared = ,831)

P< .001



Click options



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Univariate
Univariate: Options
Estimated Marginal Means
Factor(s) and Factor Interactions:
(OVERALL)
sex
method
sex*method
Display Means for:
Compare main effects
Confidence interval adjustment:
Sidak
Display
Descriptive statistics
Estimates of effect size
Observed power
Parameter estimates
Contrast coefficient matrix
Homogeneity tests
Spread vs. level plot
Residual plot
Lack of fit
General estimable function
Significance level:
,05
Confidence intervals are 95%
Continue
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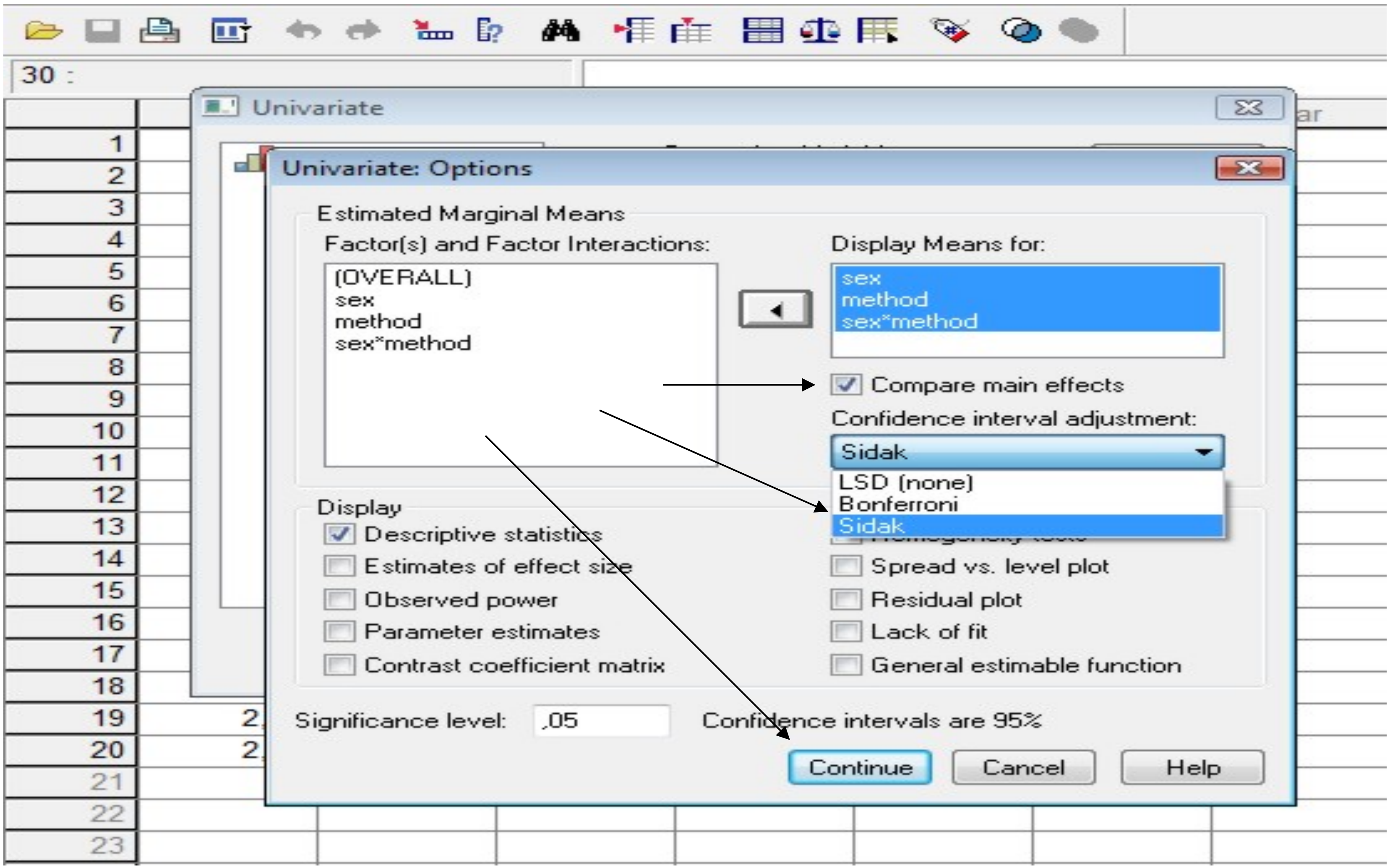
Help


30 :
Univariate
Univariate: Options
Estimated Marginal Means
Factor(s) and Factor Interactions:
(OVERALL)
sex
method
sex*method
Display Means for:
sex
method
sex*method
Compare main effects
Confidence interval adjustment:
Sidak
LSD (none)
Bonferroni
Sidak
Display
Descriptive statistics
Estimates of effect size
Observed power
Parameter estimates
Contrast coefficient matrix
Spread vs. level plot
Residual plot
Lack of fit
General estimable function
Significance level: ,05
Confidence intervals are 95%
Continue
Cancel
Help

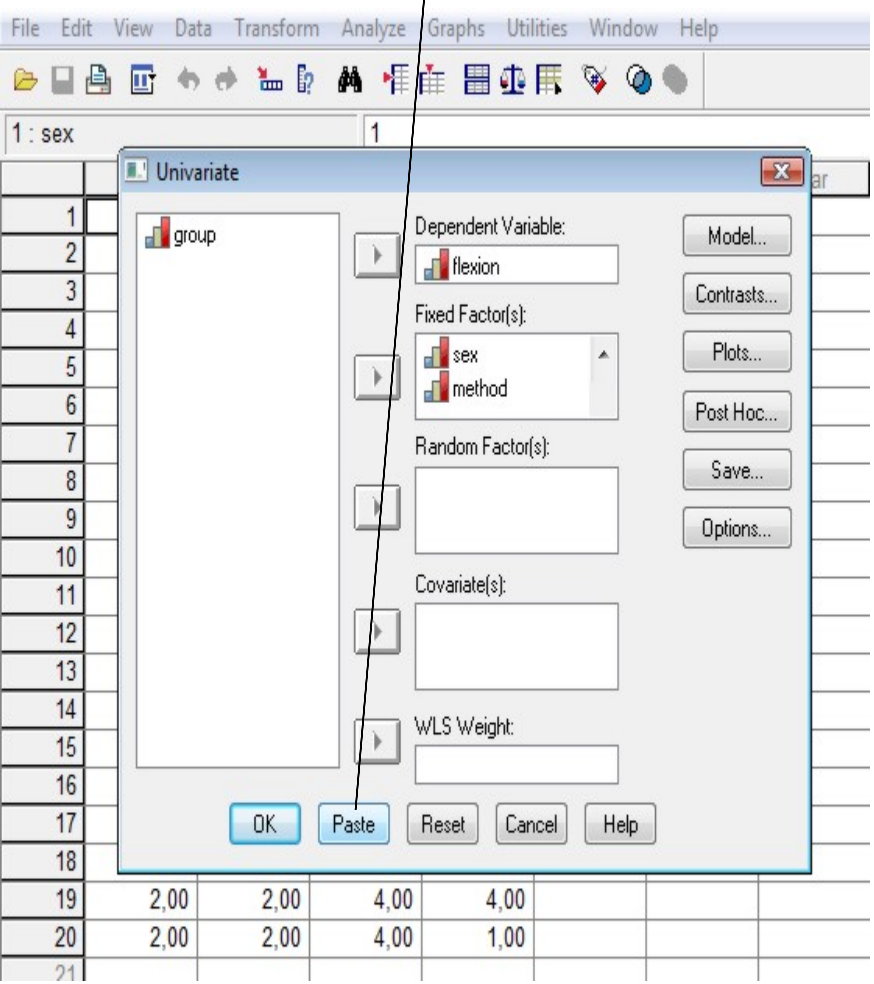
Click Paste to write syntax

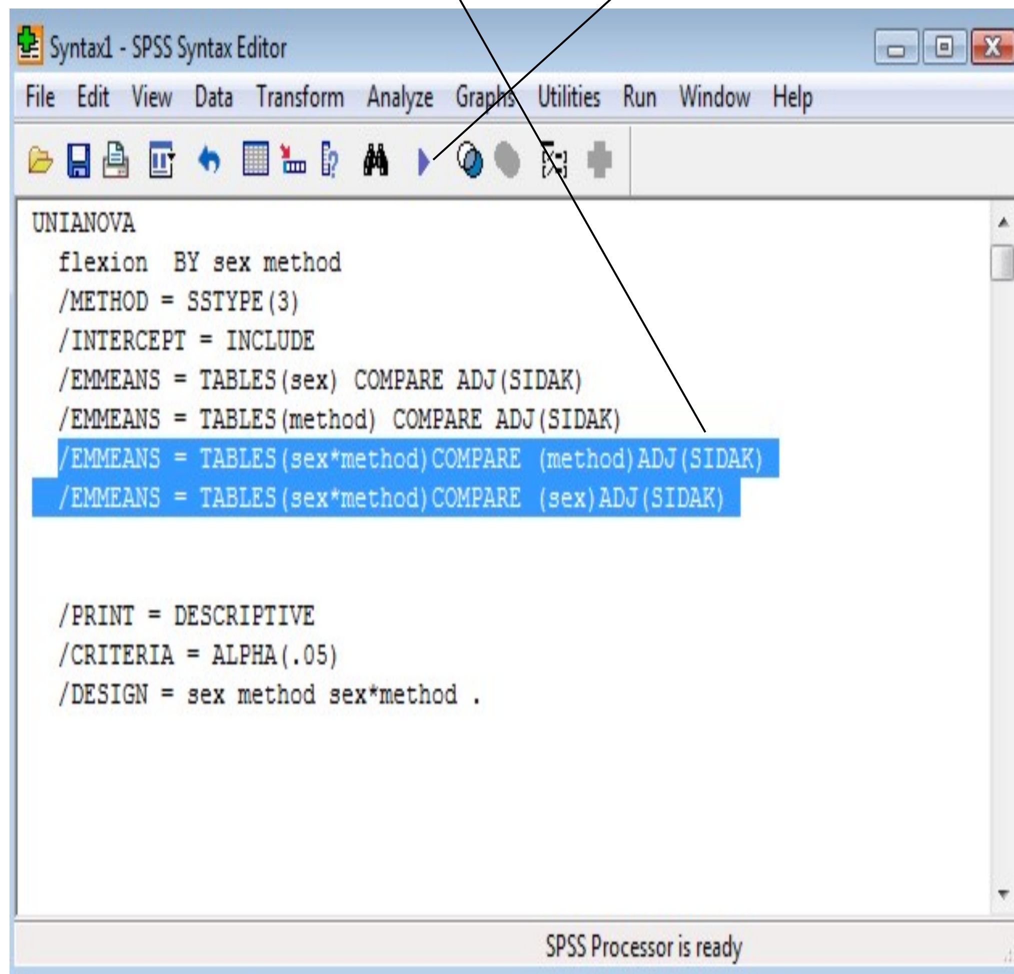
For the examination of the interaction

COMPARE (method) ADJ (SIDAK)

COMPARE (sex) ADJ (SIDAK)

Click the arrow





1. sex

Estimates

Dependent Variable: flexion

sex	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
males	5,200	,412	4,326	6,074
females	5,700	,412	4,826	6,574

Pairwise Comparisons

Dependent Variable: flexion

(I) sex	(J) sex	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	95% Confidence Interval for Difference[a] Upper Bound
males	females	-,500	,583	,404	-1,736	,736
females	males	,500	,583	,404	-,736	1,736

Based on estimated marginal means

a. Adjustment for multiple comparisons: Sidak.

No significant differences

Univariate Tests

Dependent Variable: flexion

	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	1,250	1	1,250	,735	,404	,044
Error	27,200	16	1,700			

The F tests the effect of sex. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

2. method

Estimates

Dependent Variable: flexion

method	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
passive	5,500	,412	4,626	6,374
pnf	5,400	,412	4,526	6,274

Pairwise Comparisons

Dependent Variable: flexion

(I) method	(J) method	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
passive	pnf	,100	,583	,866	-1,136	1,336
pnf	passive	-,100	,583	,866	-1,336	1,136

Based on estimated marginal means

a. Adjustment for multiple comparisons: Sidak.

No significant differences

Univariate Tests

Dependent Variable: flexion

	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	,050	1	,050	,029	,866	,002
Error	27,200	16	1,700			

The F tests the effect of method. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

3. sex * method

Estimates

Dependent Variable: flexion

sex	method	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
males	passive	2,400	,583	1,164	3,636
	pnf	8,000	,583	6,764	9,236
females	passive	8,600	,583	7,364	9,836
	pnf	2,800	,583	1,564	4,036

Pairwise Comparisons

Dependent Variable: flexion

sex	(I) method	(J) method	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
						Lower Bound	Upper Bound
males	passive	pnf	-5,600*	,825	,000	-7,348	-3,852
	pnf	passive	5,600*	,825	,000	3,852	7,348
females	passive	pnf	5,800*	,825	,000	4,052	7,548
	pnf	passive	-5,800*	,825	,000	-7,548	-4,052

Based on estimated marginal means

*. The mean difference is significant at the ,050 level.

a. Adjustment for multiple comparisons: Sidak.

4. sex * method

Estimates

Dependent Variable: flexion

sex	method	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
males	passive	2,400	,583	1,164	3,636
	pnf	8,000	,583	6,764	9,236
females	passive	8,600	,583	7,364	9,836
	pnf	2,800	,583	1,564	4,036

Pairwise Comparisons

Dependent Variable: flexion

method	(I) sex	(J) sex	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
						Lower Bound	Upper Bound
passive	males	females	-6,200*	,825	,000	-7,948	-4,452
	females	males	6,200*	,825	,000	4,452	7,948
pnf	males	females	5,200*	,825	,000	3,452	6,948
	females	males	-5,200*	,825	,000	-6,948	-3,452

Based on estimated marginal means

*. The mean difference is significant at the ,050 level.

a. Adjustment for multiple comparisons: Sidak.

How to report

- We conducted a 2x2 ANOVA to determine the differences in the effectiveness of PNF and passive flexibility training with males and females. The results revealed no significant gender effect, $F(1,16) = .74$, $p =.40$, nor a significant method effect $F(1,16) = .03$, $p = .87$, but a significant interaction effect, $F(1,16) = 95.56$, $p < .001$. Pairwise comparisons revealed that passive flexibility is significantly more effective than PNF for females ($p < .001$), but PNF is significantly more effective than passive for males ($p < .001$).

Examples – How to report

Two-way ANOVA
significant main effect
non significant interaction effect

We conducted 2x2 ANOVA to examine differences in ego orientations between gender and class (5th and 6th grade). The results showed significant main effect for gender, $F\ (1,155) = 3.93,\ p < .05$, non significant effect for classroom, $F\ (1,155) = 2.18,\ p = .14$, and non significant interaction effect $F\ (1,155) = 1.54,\ p = .22$. The examination of the means showed that females had higher scores than males in ego orientations.

Two-way ANOVA
No significant main effect
Significant interaction effect

We conducted 2x2 ANOVA to examine differences in ego orientations between gender and class (5^{th} and 6^{th} grade). The results showed non significant effect for gender, $F(1,155) = 2.91$, $p = .09$, non significant effect for classroom, $F(1,155) = .32$, $p = .57$, but statistical interaction effect, $F(1,155) = 3.96$, $p < .05$. For the examination of the interaction effect, pairwise analysis showed that although in the 5^{th} grade there were no significant differences between boys and girls in the 6th grade boys had higher scores than girls in ego orientations.

Two-way ANOVA
Significant main effect
Significant interaction effect

We conducted 2x2 ANOVA to examine differences in ego orientations between gender and class (5^{th} and 6^{th} grade). The results showed significant main effect for gender, $F(1,155) = 18.21$, $p < .01$, and classroom, $F(1,155) = 21.48$, $p < .01$, and statistical interaction effect $F(1,155) = 7.48$, $p < .01$. Pairwise analysis showed that although in the 5^{th} grade there were no significant differences between boys and girls in the 6sth grade boys had higher scores than girls in ego orientations.