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ESTADÍSTICA DESCRIPTIVA II: ESTADÍSTICA DESCRIPTIVA BIVARIANT

Curs d'Estadística Bàsica per a la Recerca Biomèdica

UEB – VHIR

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Institució CERCA Centres de Recerca de Catalunya
Instituto de Salud Carlos III

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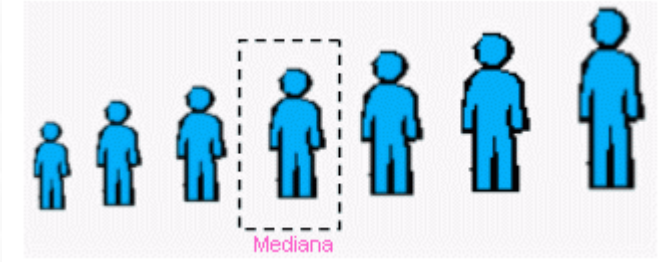
1. From univariate to Bivariate analysis

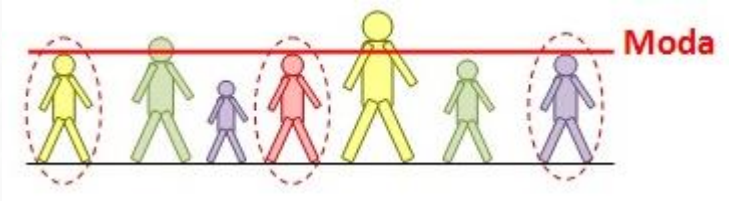
On Monday we learned…

- We can analyse and describe each variable one by one:

    1. **With some measures:**

Measures of central tendency

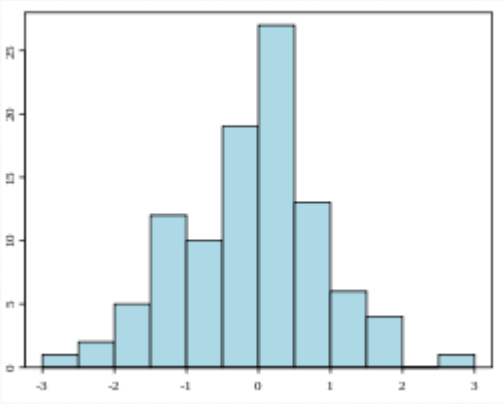


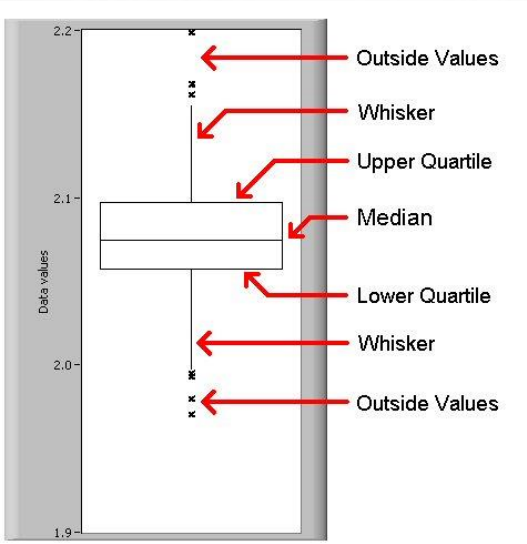


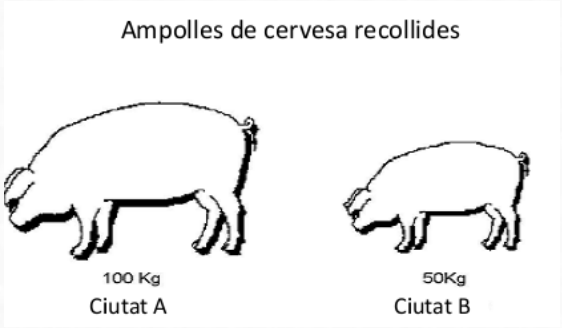
Measures of dispersion

1. From univariate to Bivariate analysis

2. Some graphics







1. From univariate to Bivariate analysis

- In univariate analysis **only one** variable is analyzed each time

the purpose of the analysis is **descriptive**

- If there are more than one variable in the dataset it could be interesting to guess if:
  - Does exist a relation between the two variables?
  - How important is this relation?
  - Which is the direction of the relation?

1. From univariate to Bivariate analysis

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	registro	area	f_nac	edad	grupedad	peso	talla	bua	imc	clasific	me
1	3	10	11659420800	57	55 - 59	70.0	168.0	69	24.80159	OSTEOPENIA	
2	4	10	11671689600	46	45 - 49	53.0	152.0	73	22.93975	OSTEOPENIA	
3	10	10	11721024000	45	45 - 49	64.0	158.0	81	25.63692	NORMAL	
4	11	10	11464416000	53	50 - 54	78.0	161.0	58	30.09143	OSTEOPENIA	
5	12	10	11690784000	46	45 - 49	56.0	157.0	89	22.71897	NORMAL	
6	15	10	11716012800	45	45 - 49	63.5	170.0	76	21.97232	NORMAL	
7	16	10	11623737600	48	45 - 49	86.0	161.0	87	33.17773	NORMAL	
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21	31	10	11633155200	48	45 - 49	66.5	153.0	11	28.40788	OSTEOPOROSIS	
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23	34	10	10992758400	68	65 - 69	66.5	145.0	57	31.62901	OSTEOPENIA	
24	35	10	10909382400	69	65 - 69	70.0	168.0	48	24.80159	OSTEOPOROSIS	
25	36	10	11643868800	48	45 - 49	60.1	153.0	86	25.67389	NORMAL	
26	37	10	11551420800	50	50 - 54	67.0	159.0	105	26.50212	NORMAL	
27	38	10	11043907200	66	65 - 69	67.0	144.0	79	32.31096	NORMAL	
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Bivariate analysis

- Involves the analysis of **two** variables for the purpose of determining the empirical relationship between them.

easiest way is to measure how those two variables simultaneously change together

Bivariate analysis

- Involves the analysis of **two** variables for the purpose of determining the empirical relationship between them.

easiest way is to measure how those two variables simultaneously change together

- Major differentiating point between *univariate and bivariate* analysis (a part from the number of variables implicated) is that bivariate analysis goes beyond simply **descriptive**, since it study the **relationship** between the two variables.

Why bivariate analysis?

Let's begin by asking if:

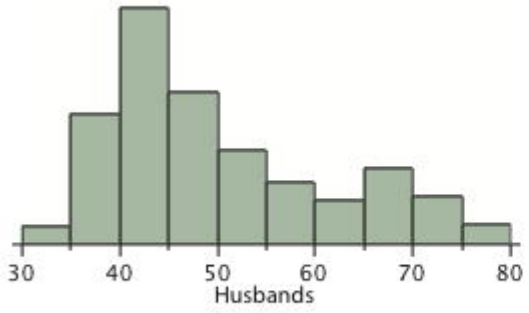
People tend to marry other people of about the same age?

Our experience tells us "yes", but how good is the correspondence?

Husband	36	72	37	36	51	50	47	50	37	41
Wife	35	67	33	35	50	46	47	42	36	41

Sample of spousal ages of 10 White American Couples

Why bivariate analysis?



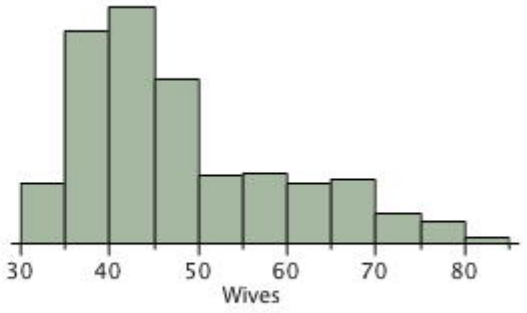


Figure 1. Histograms of spousal ages.

	Mean	Standard Deviation
Husbands	49	11
Wives	47	11

Onlinestatbook (Authors: Rudy Guerra and David M. Lane)

Why bivariate analysis?

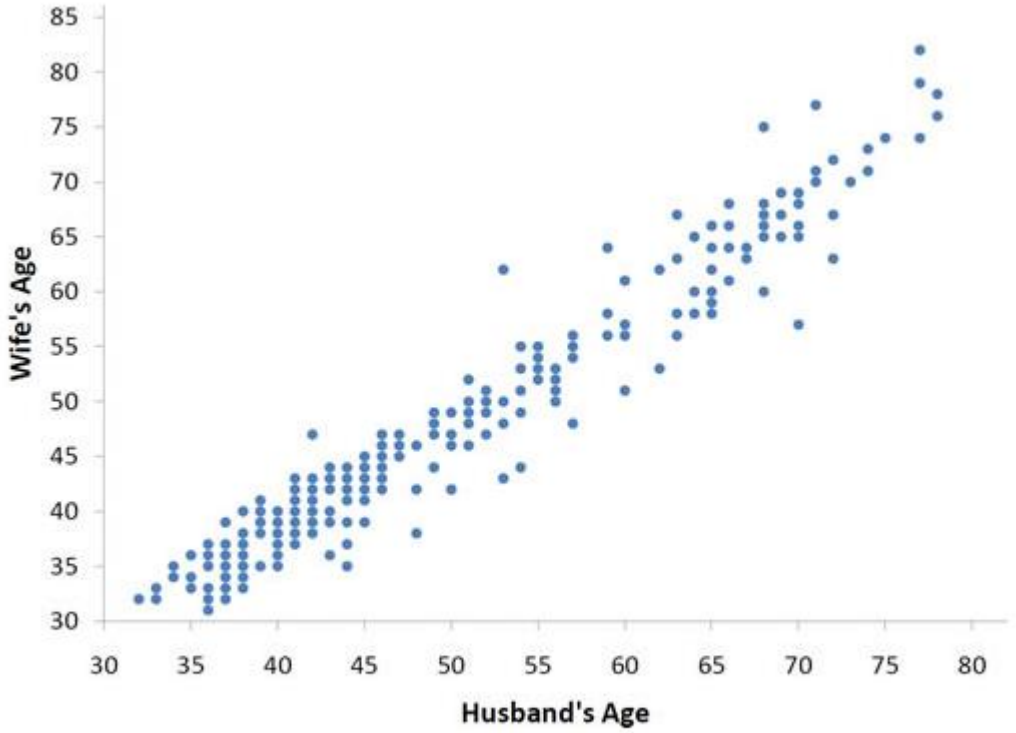


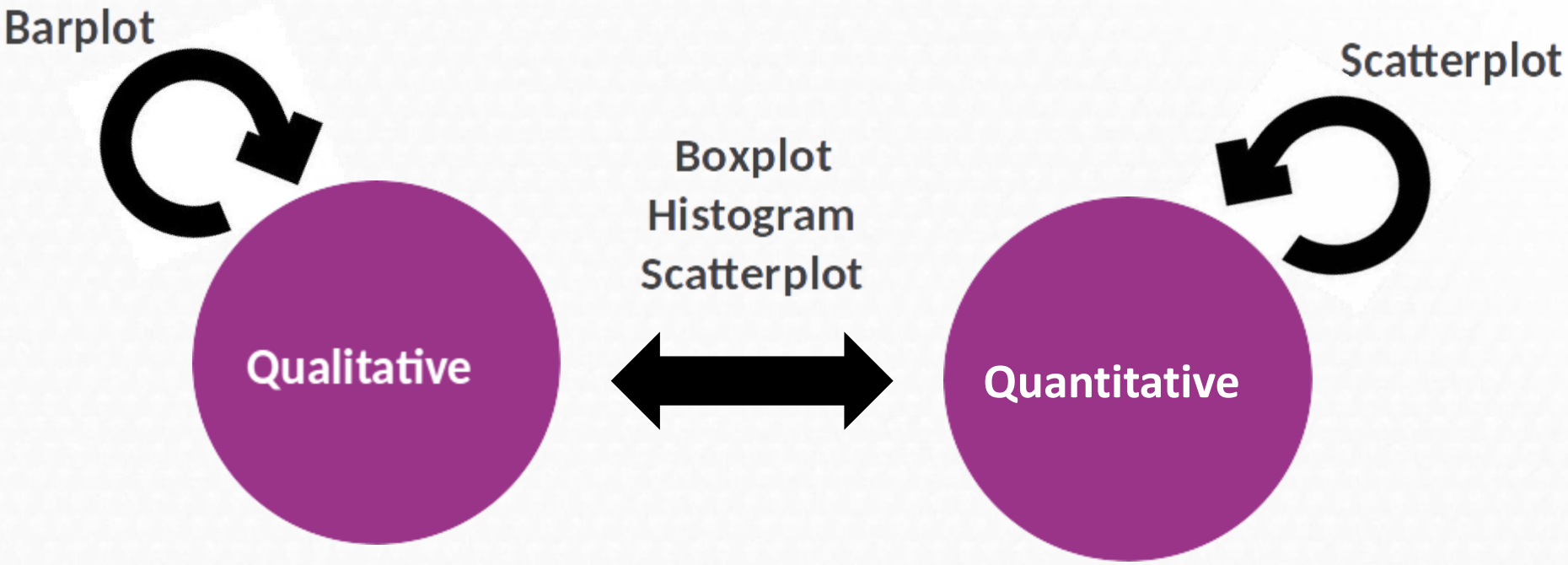
Figure 2. Scatter plot showing wife's age as a function of husband's age.

- The older the husband the older the wife.
- It is possible to know age of wives for an husband age.

Onlinestatbook (Authors: Rudy Guerra and David M. Lane)

2. Bivariate analysis

Some plots to study the relationship between two variables...



2. Bivariate analysis

2.1 Qualitative versus qualitative

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The way to study the relation will depend on the variable types:

- Two **qualitative** variables: contingency table

Used for organizing categorical variables and testing hypothesis with the chi-squared test for independence

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The way to study the relation will depend on the variable types:

- Two **qualitative** variables: contingency table

Used for organizing categorical variables and testing hypothesis with the chi-squared test for independence

- Count of individuals that simultaneously presents variable 1 (x) and variable 2 (y)

	y_1	y_1	$\cdots$	y_p	$n_{i.}$
x_1	n_{11}	n_{12}	$\cdots$	n_{1p}	$n_{1.}$
x_2	n_{21}	n_{22}	$\cdots$	n_{2p}	$n_{2.}$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
x_k	n_{k1}	n_{k2}	$\cdots$	n_{kp}	$n_{k.}$
$n_{.j}$	$n_{.1}$	$n_{.2}$	$\cdots$	$n_{.p}$	N

Absolute

$$f_{ij} = \frac{n_{ij}}{N}$$

	y_1	y_1	$\cdots$	y_p	$f_{i.}$
x_1	f_{11}	f_{12}	$\cdots$	f_{1p}	$f_{1.}$
x_2	f_{21}	f_{22}	$\cdots$	f_{2p}	$f_{2.}$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
x_k	f_{k1}	f_{k2}	$\cdots$	f_{kp}	$f_{k.}$
$f_{.j}$	$f_{.1}$	$f_{.2}$	$\cdots$	$f_{.p}$	1

relative

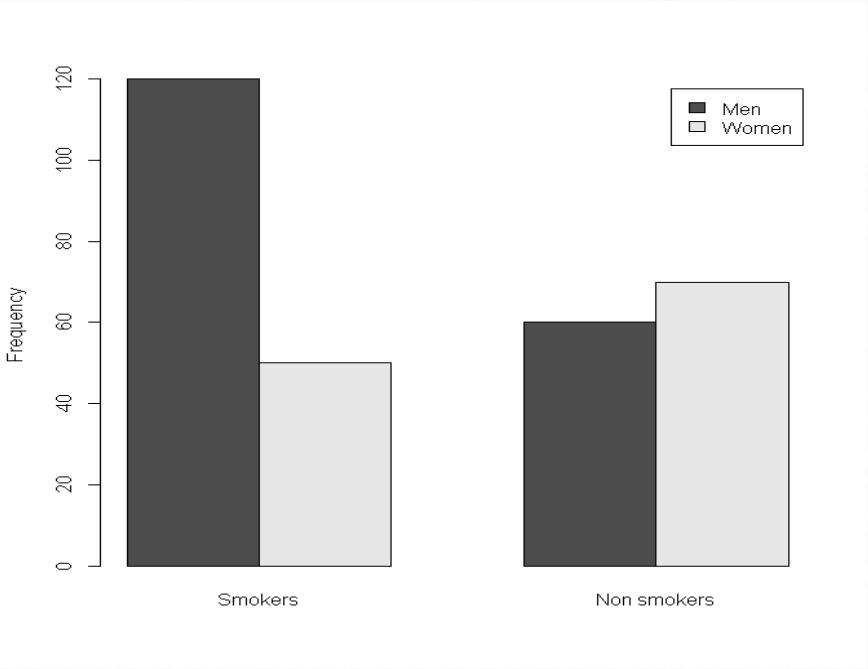
2. Bivariate analysis

2.1 Qualitative versus qualitative

An study wants to know if there are differences about smoking habits in men and women.

Gender	Smoking habits
1	1
2	1
1	0
1	0
1	0
1	1
2	1
...	...

	Smokers	Non Smoking	Total
Men	120	60	180
Women	50	70	120
Total	170	130	300



2. Bivariate analysis
2.1 Qualitative versus qualitative

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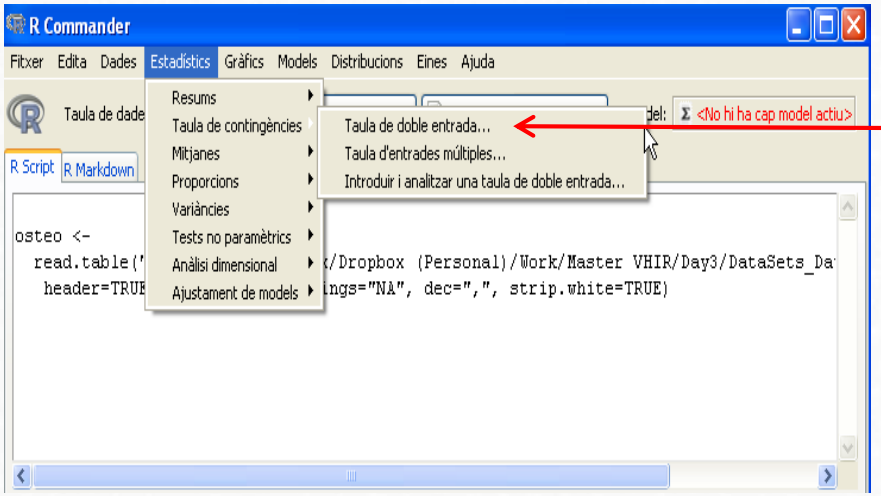
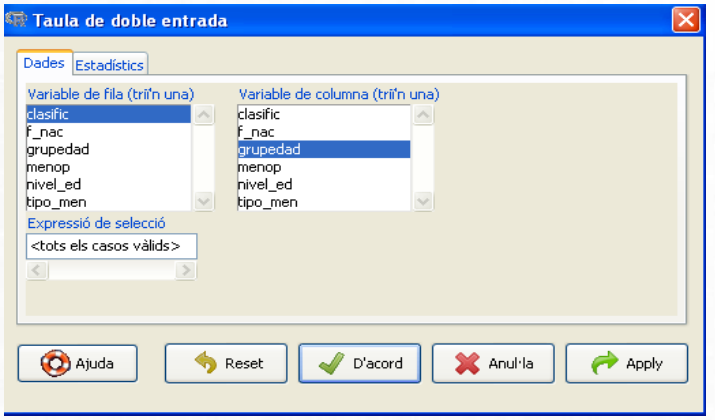
Let´s do in R Commander: Osteoporosis dataset

Study if the group age (*grupedad*) of patients, influence in the illness type *(classific):*





2. Bivariate analysis

2.1 Qualitative versus qualitative

Frequency table:

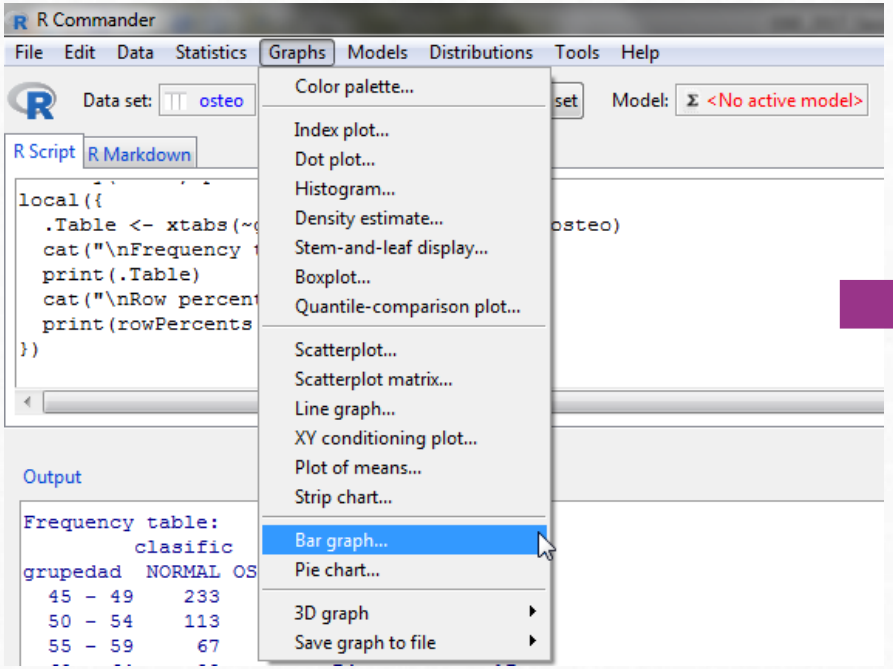
grupedad	clasific NORMAL	OSTEOPENIA	OSTEOPOROSIS
45 - 49	233	138	7
50 - 54	113	113	7
55 - 59	67	100	9
60 - 64	38	74	17
65 - 69	18	42	24

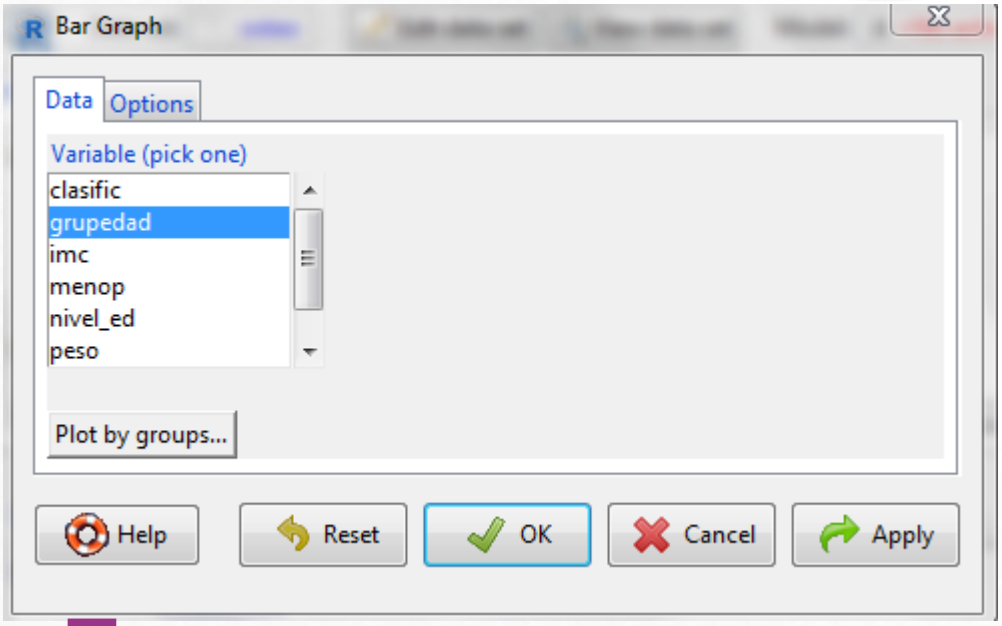
Total percentages:

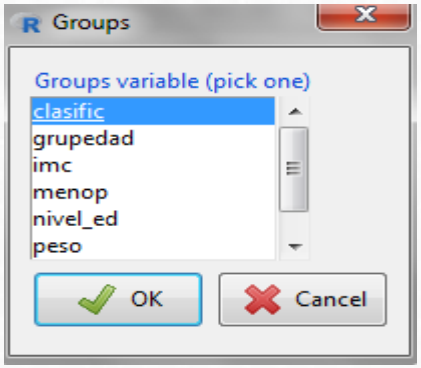
	NORMAL	OSTEOPENIA	OSTEOPOROSIS	Total
45 - 49	23.3	13.8	0.7	37.8
50 - 54	11.3	11.3	0.7	23.3
55 - 59	6.7	10.0	0.9	17.6
60 - 64	3.8	7.4	1.7	12.9
65 - 69	1.8	4.2	2.4	8.4
Total	46.9	46.7	6.4	100.0

2. Bivariate analysis

2.1 Qualitative versus qualitative

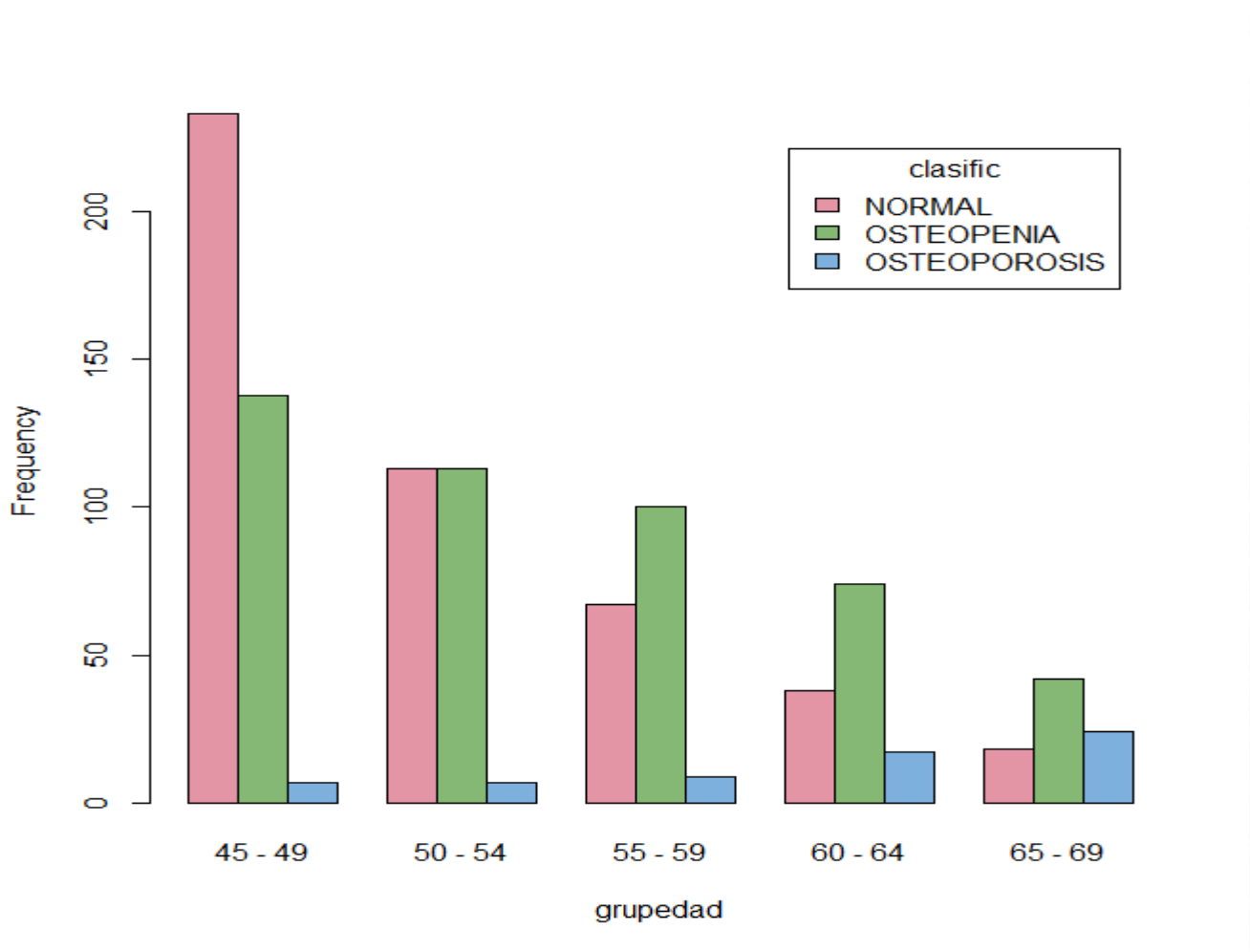






2. Bivariate analysis

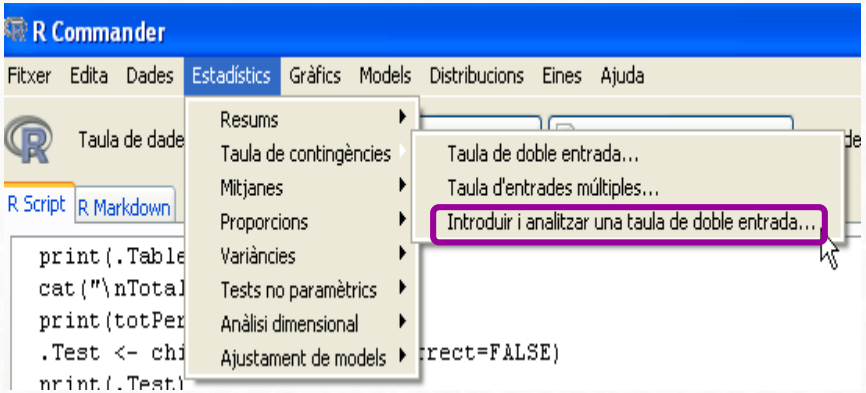
2.1 Qualitative versus qualitative

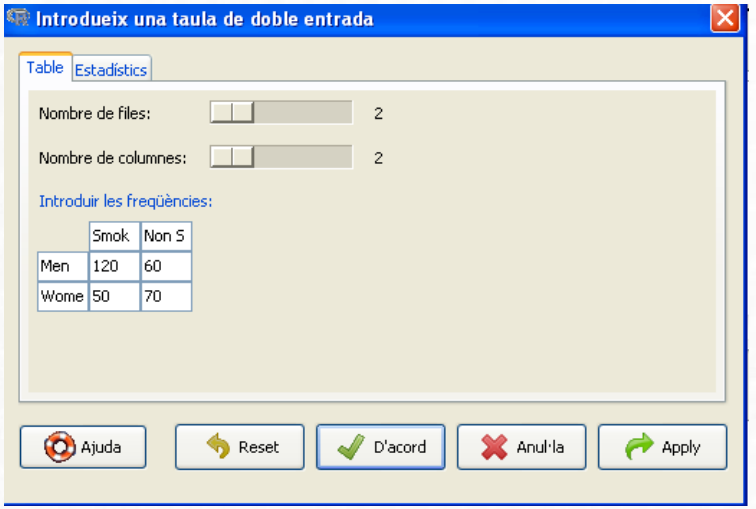


2. Bivariate analysis
2.1 Qualitative versus qualitative

Another way to introduce the data:

	Smokers	Non Smoking	Total
Men	120	60	180
Women	50	70	120
Total	170	130	300





2. Bivariate analysis
2.1 Qualitative versus qualitative

Another way to introduce the data:

	Smokers	Non Smoking	Total
Men	120	60	180
Women	50	0	120
Total	170	130	300

```
> .Table  # Counts
     1  2
1 120 60
2  50 70

> totPercents(.Table) # Percentage of Total
          1    2 Total
1      40.0 20.0    60
2      16.7 23.3    40
Total 56.7 43.3   100
```

2. Bivariate analysis

2.2 Qualitative versus quantitative

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osteo

	registro	area	f_nac	edad	grupedad	peso	talla	bua	imc	clasific	me
1	3	10	11659420800	57	55 - 59	70.0	168.0	69	24.80159	OSTEOPENIA	
2	4	10	11671689600	46	45 - 49	53.0	152.0	73	22.93975	OSTEOPENIA	
3	10	10	11721024000	45	45 - 49	64.0	158.0	81	25.63692	NORMAL	
4	11	10	11464416000	53	50 - 54	78.0	161.0	58	30.09143	OSTEOPENIA	
5	12	10	11690784000	46	45 - 49	56.0	157.0	89	22.71897	NORMAL	
6	15	10	11716012800	45	45 - 49	63.5	170.0	76	21.97232	NORMAL	
7	16	10	11623737600	48	45 - 49	86.0	161.0	87	33.17773	NORMAL	
8	17	10	11562307200	50	50 - 54	61.5	164.0	74	22.86585	NORMAL	
9	18	10	11538028800	51	50 - 54	60.5	158.0	58	24.23490	OSTEOPENIA	
10	20	10	11332483200	57	55 - 59	64.0	149.0	61	28.82753	OSTEOPENIA	
11	21	10	11631945600	48	45 - 49	70.3	160.0	67	27.46094	OSTEOPENIA	
12	22	10	11425536000	55	55 - 59	74.4	160.0	68	29.06250	OSTEOPENIA	
13	23	10	11553235200	50	50 - 54	55.5	154.5	73	23.25070	OSTEOPENIA	
14	24	10	11367302400	56	55 - 59	89.0	166.0	61	32.29787	OSTEOPENIA	
15	25	10	11585635200	49	45 - 49	50.6	157.0	68	20.52822	OSTEOPENIA	
16	26	10	11572156800	50	50 - 54	71.4	152.0	74	30.90374	NORMAL	
17	27	10	11590992000	49	45 - 49	78.0	157.0	62	31.64429	OSTEOPENIA	
18	28	10	11293516800	58	55 - 59	72.0	162.0	65	27.43484	OSTEOPENIA	
19	29	10	11215238400	61	60 - 64	68.0	155.5	65	28.12212	OSTEOPENIA	
20	30	10	11405664000	55	55 - 59	75.0	161.0	92	28.93407	NORMAL	
21	31	10	11633155200	48	45 - 49	66.5	153.0	11	28.40788	OSTEOPOROSIS	
22	32	10	11287728000	59	55 - 59	101.0	156.0	82	41.50230	NORMAL	
23	34	10	10992758400	68	65 - 69	66.5	145.0	57	31.62901	OSTEOPENIA	
24	35	10	10909382400	69	65 - 69	70.0	168.0	48	24.80159	OSTEOPOROSIS	
25	36	10	11643868800	48	45 - 49	60.1	153.0	86	25.67389	NORMAL	
26	37	10	11551420800	50	50 - 54	67.0	159.0	105	26.50212	NORMAL	
27	38	10	11043907200	66	65 - 69	67.0	144.0	79	32.31096	NORMAL	
28	39	10	10948089600	69	65 - 69	70.5	148.5	40	31.96953	OSTEOPOROSIS	
29	40	10	11051251200	66	65 - 69	66.5	147.0	48	30.77421	OSTEOPOROSIS	
30	41	10	11333692800	57	55 - 59	58.5	142.0	80	29.01210	NORMAL	

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The way to study the relation will depend on the variable types:

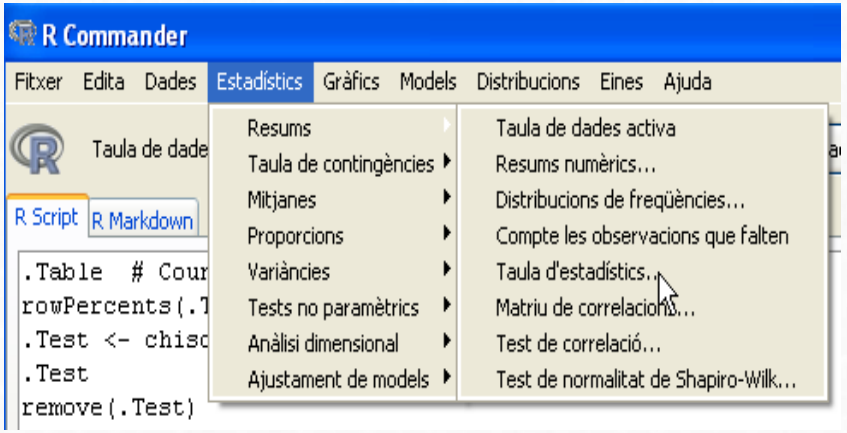
- One **qualitative** variable and one **quantitative** variable: Table of statistics

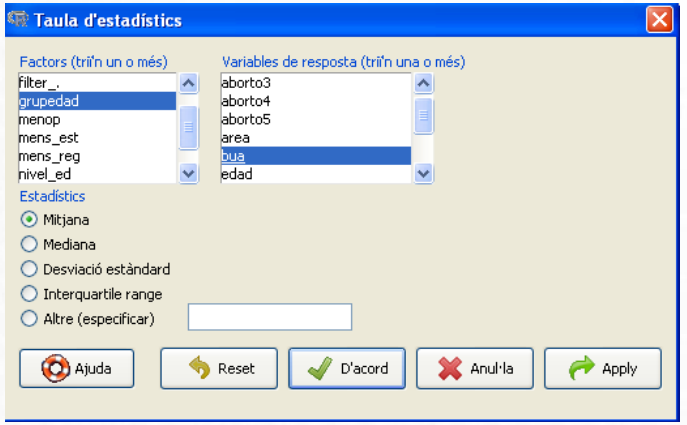
Mean value of the variable in each category for each individual

2. Bivariate analysis
2.2 Qualitative versus quantitative

Let´s do in R Commander: Osteoporosis dataset

Study if bone density (*bua)* how change in each group of age





2. Bivariate analysis
2.2 Qualitative versus quantitative

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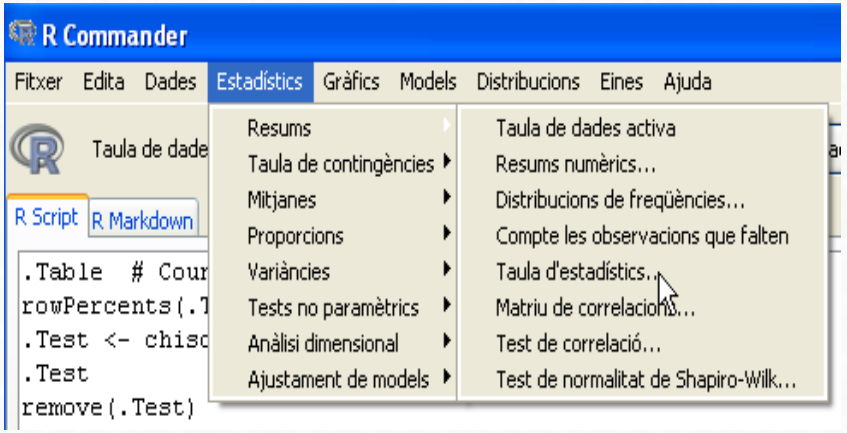
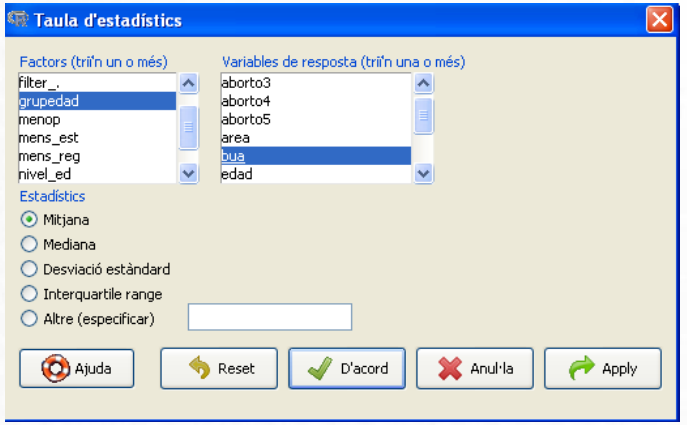
Let´s do in R Commander: Osteoporosis dataset

Study if bone density (*bua)* how change in each group of age

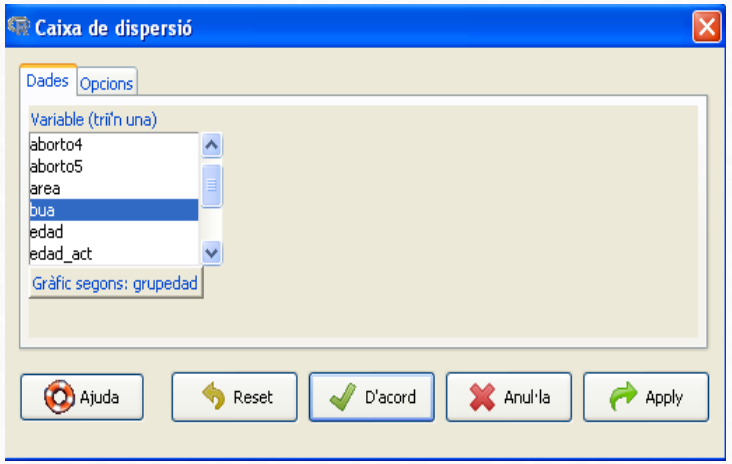


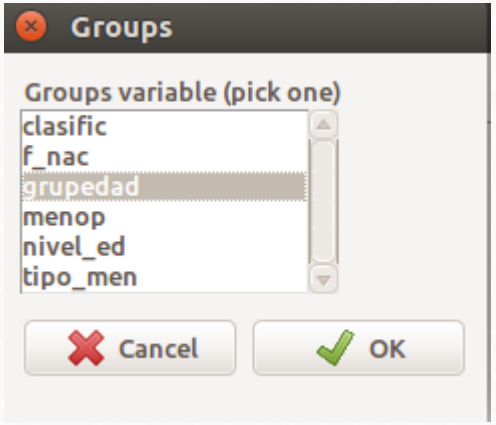


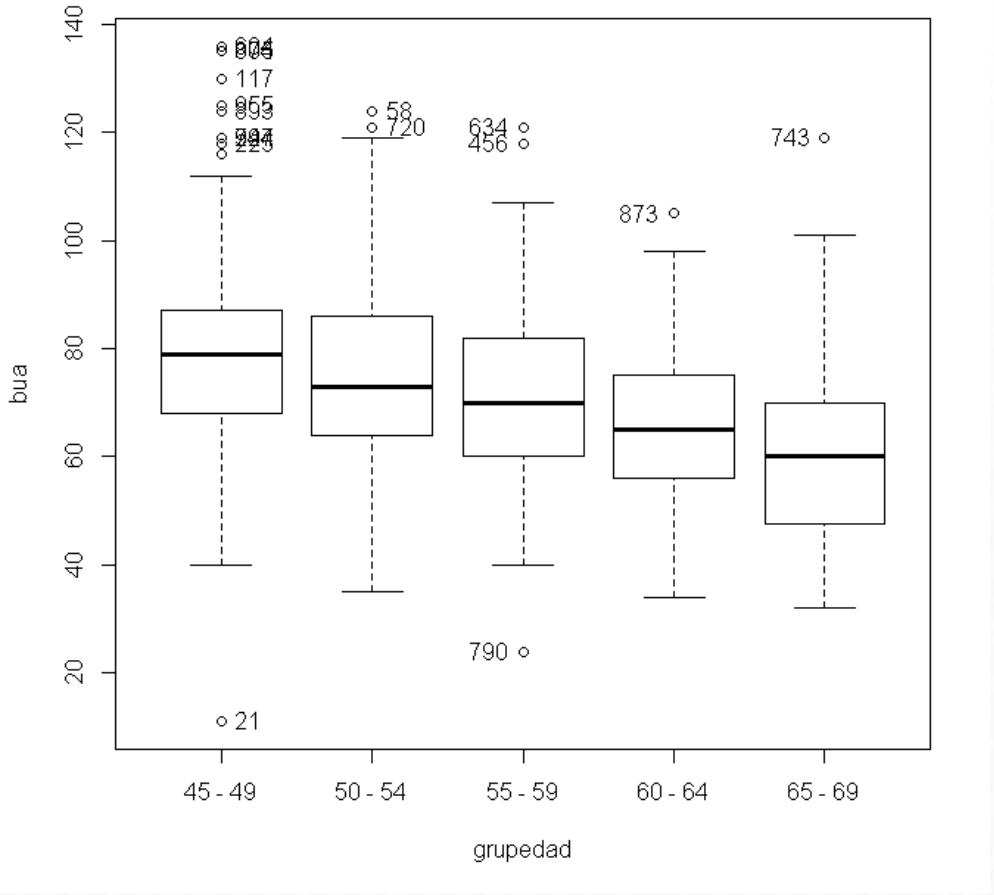

```
> with(osteo, tapply(bua, list(grupedad), mean, na.rm=TRUE))
   45-49    50-54    55-59    60-64    65-69
78.75926 75.05150 71.43182 64.89147 60.66667
```

2. Bivariate analysis
2.2 Qualitative versus quantitative

Study if bone density (*bua)* is different in each group of age

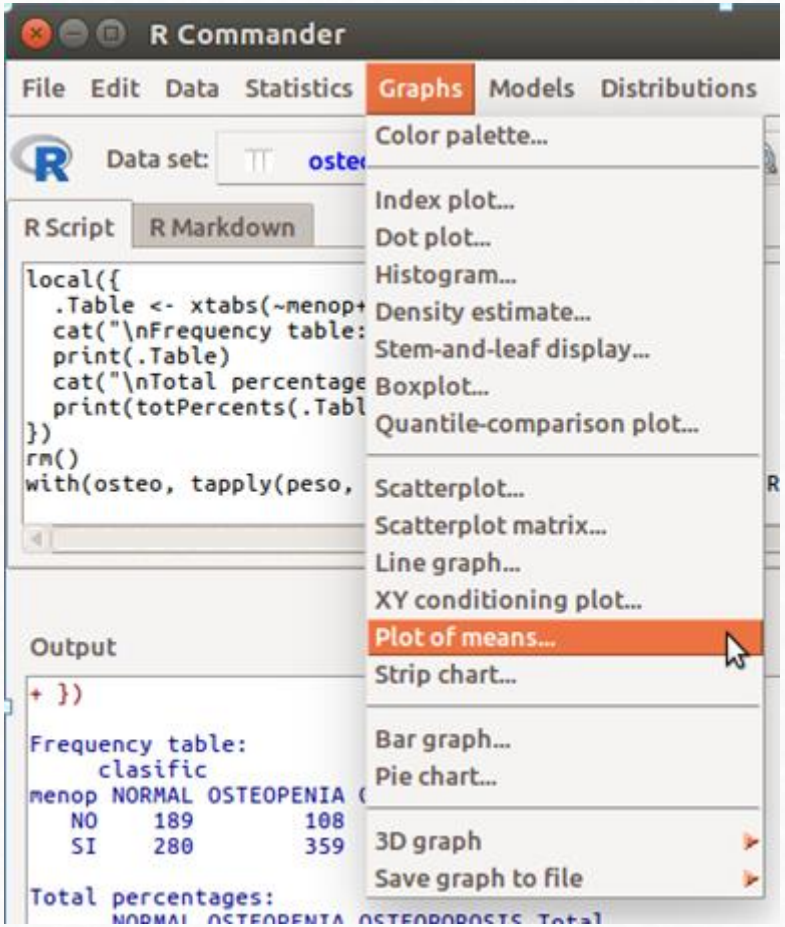


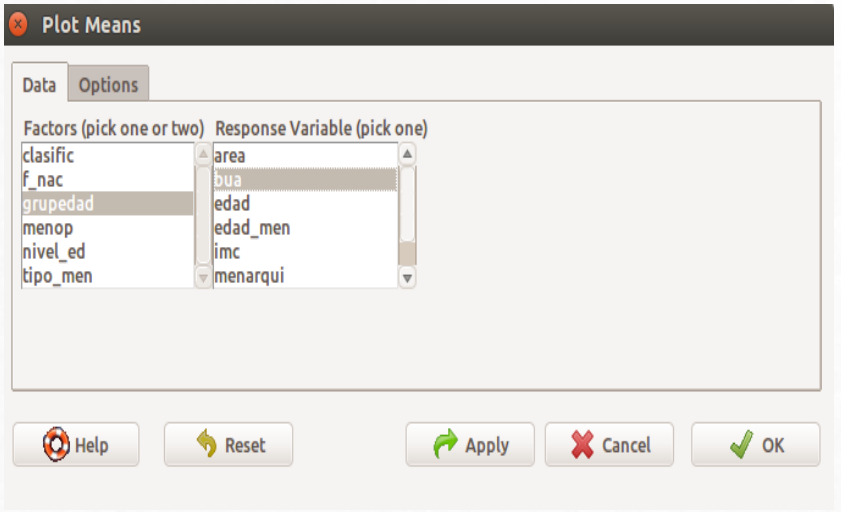




2. Bivariate analysis
2.2 Qualitative versus quantitative

Study if bone density (*bua)* is different in each group of age

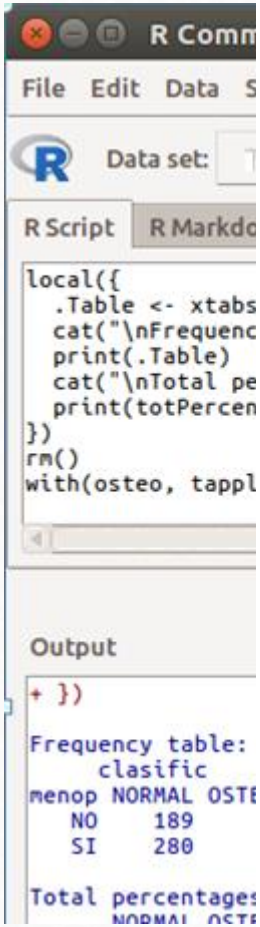


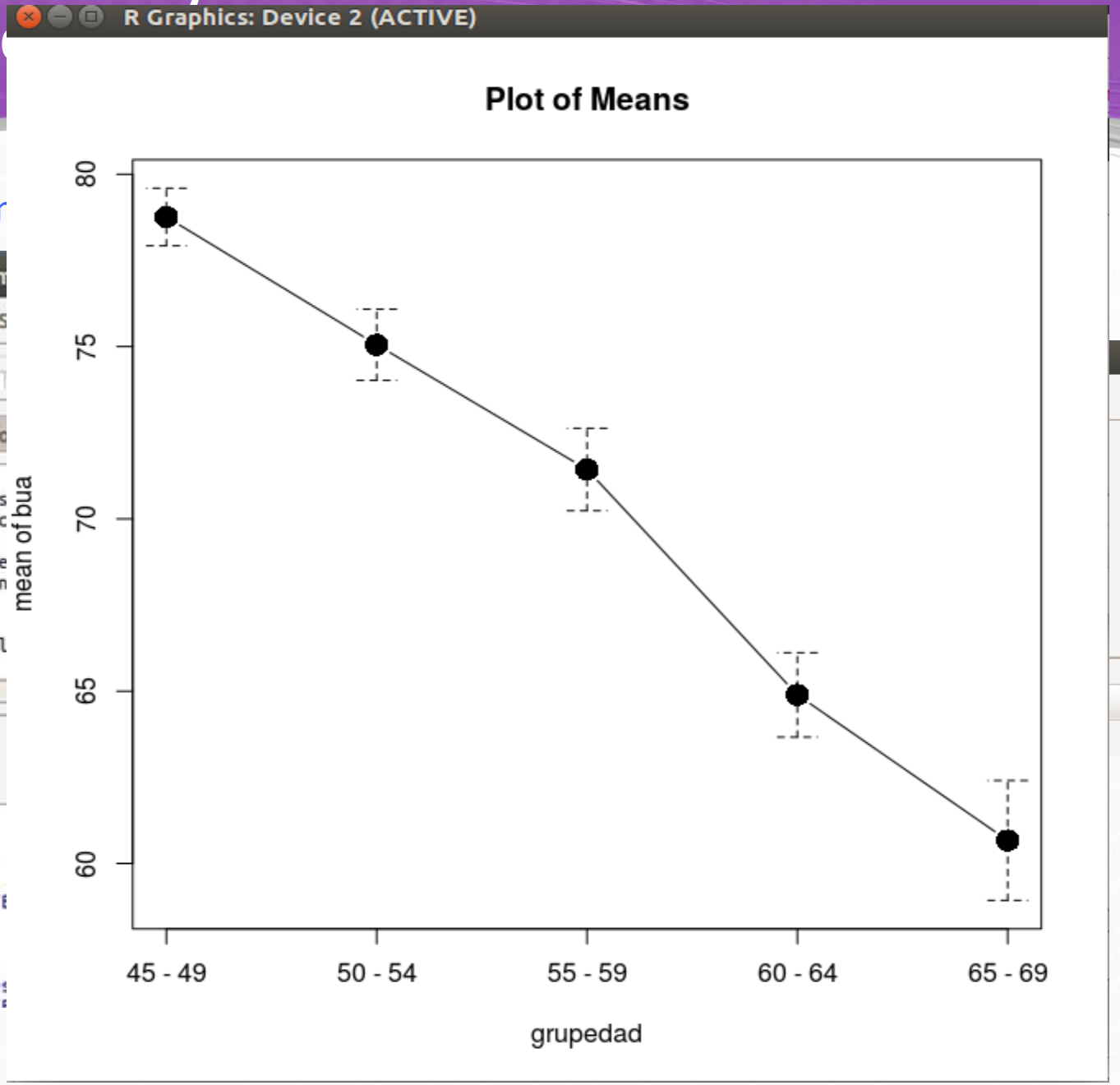


2. Bivariate analysis

2.2

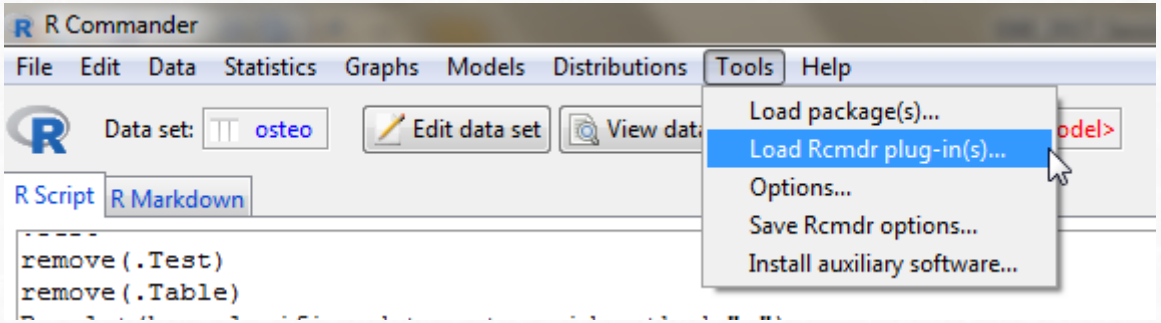
Study if bor

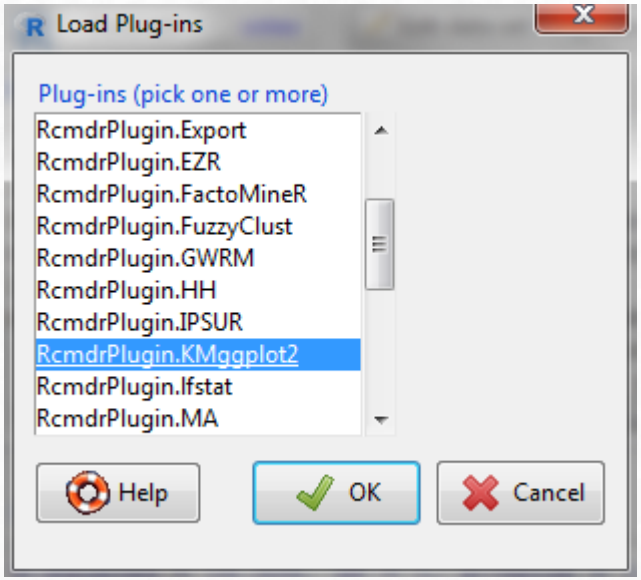




2. Bivariate analysis
2.2 Qualitative versus quantitative

Graphics with KMggplots2:





2. Bivariate analysis
2.2 Qualitative versus quantitative

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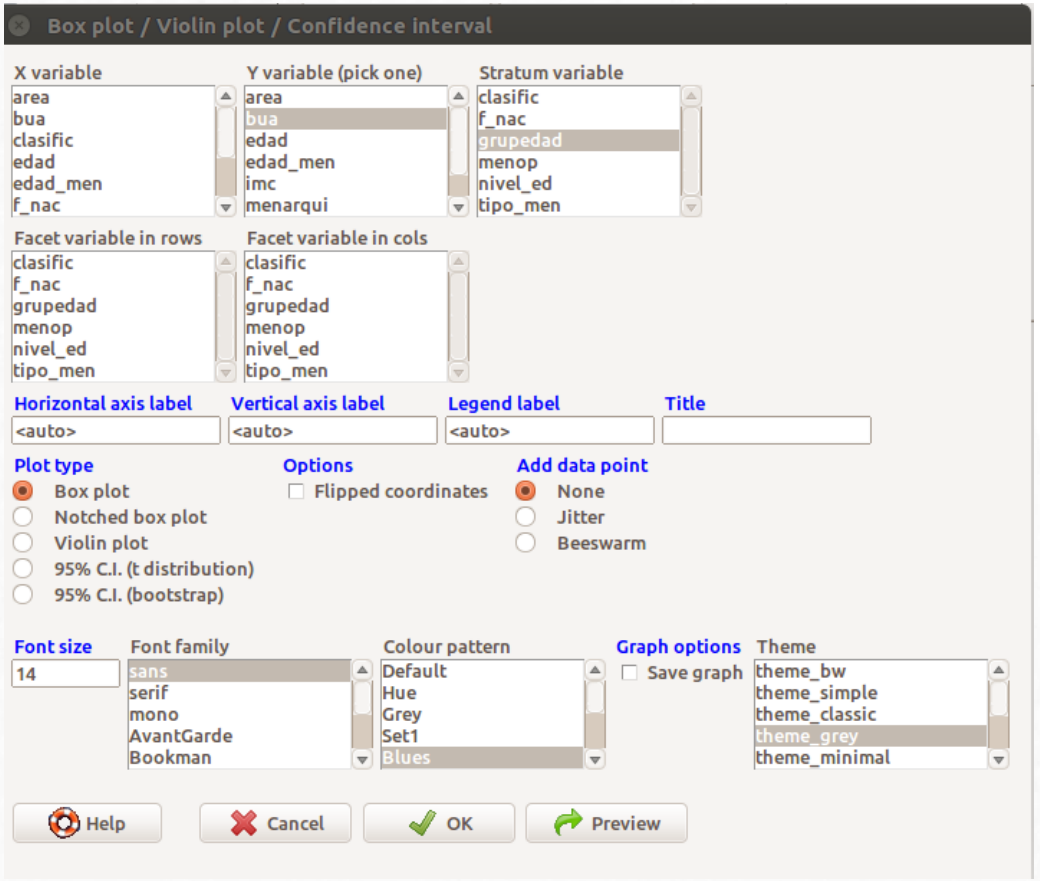
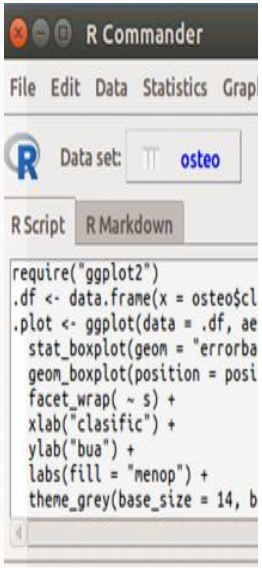
Study if bone density (*bua)* is different in each group of age **(with KMggplot2)**

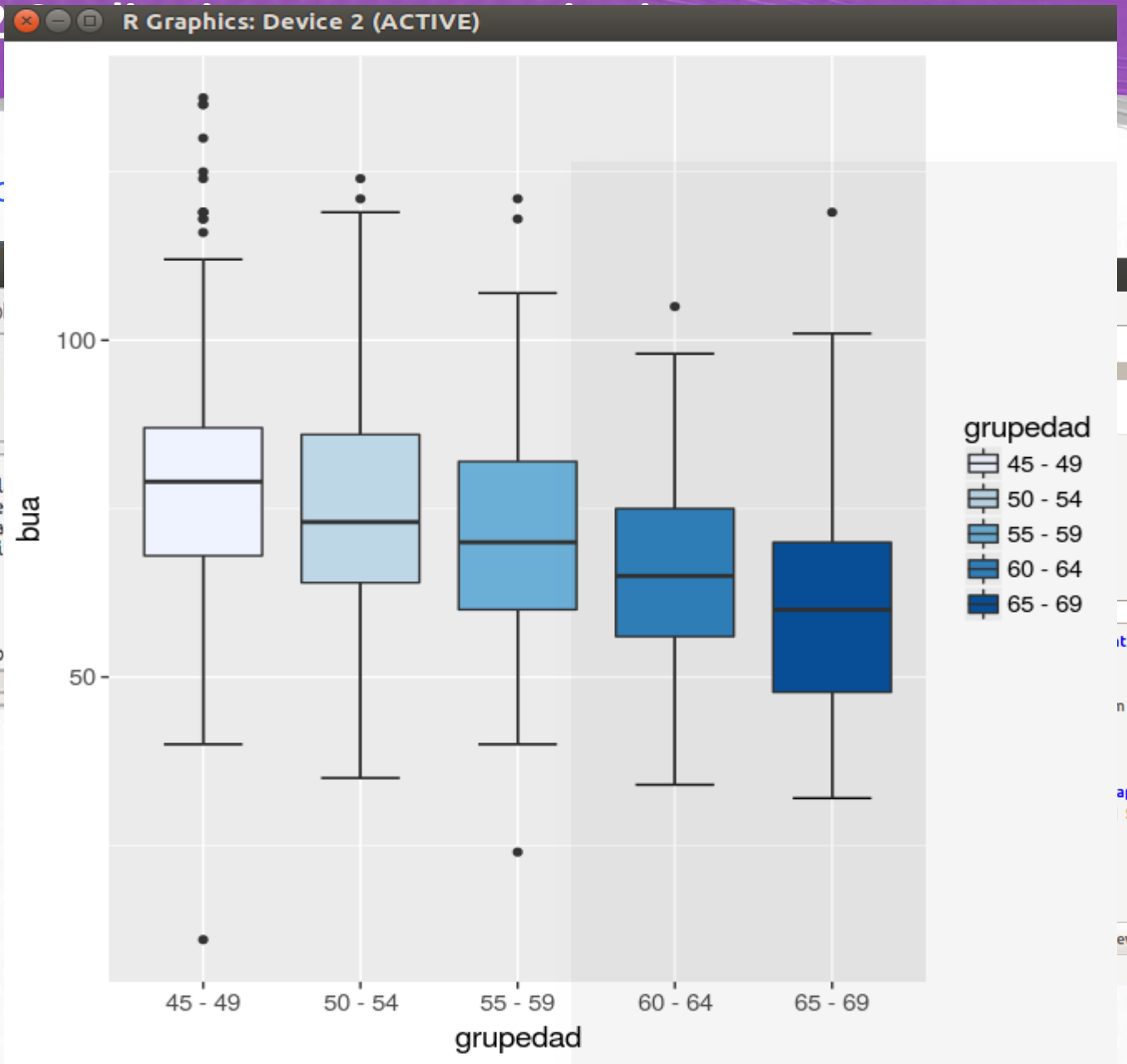


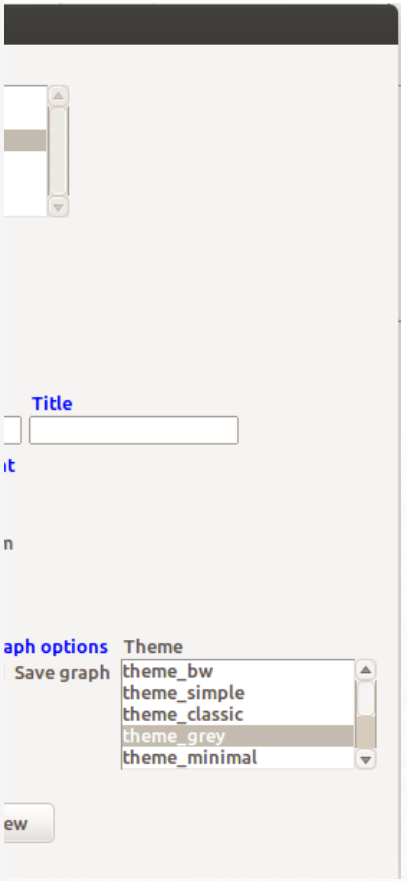
2. Bivariate analysis

2.2

Study if bc



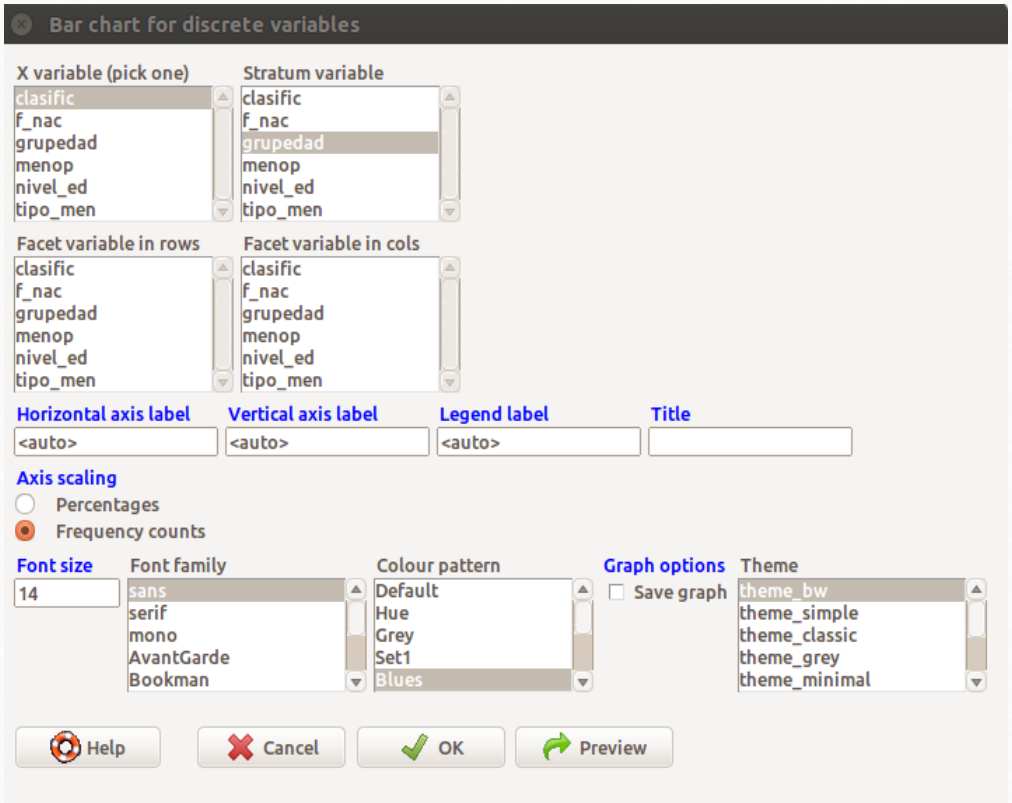


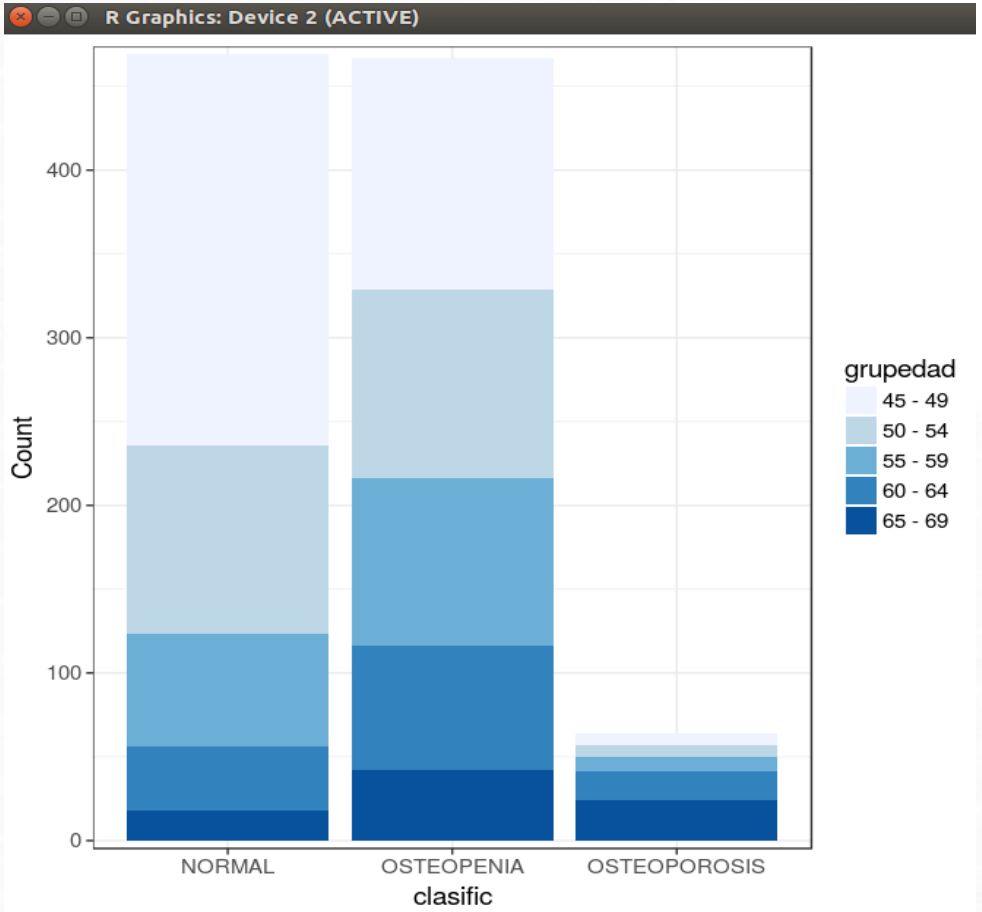


2. Bivariate analysis

2.1 Qualitative versus qualitative

Study if *grupedad*, influence in the illness type *(classific)* **(with KMgglplots2)**





2. Bivariate analysis

Exercise

Study if the relationship between *menop* and group of illness (*classific*)

Study if *peso* is different in each group of illness (*classific*).

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The way to study the relation will depend on the variable types:

- Two **quantitatives** variables:

2. Bivariate analysis

2.3 Quantitative versus Quantitative

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The v…pes:

- Two…

osteo

	registro	area	f_nac	edad	grupedad	peso	talla	bua	imc	clasific	me
1	3	10	11659420800	57	55 - 59	70.0	168.0	69	24.80159	OSTEOPENIA	
2	4	10	11671689600	46	45 - 49	53.0	152.0	73	22.93975	OSTEOPENIA	
3	10	10	11721024000	45	45 - 49	64.0	158.0	81	25.63692	NORMAL	
4	11	10	11464416000	53	50 - 54	78.0	161.0	58	30.09143	OSTEOPENIA	
5	12	10	11690784000	46	45 - 49	56.0	157.0	89	22.71897	NORMAL	
6	15	10	11716012800	45	45 - 49	63.5	170.0	76	21.97232	NORMAL	
7	16	10	11623737600	48	45 - 49	86.0	161.0	87	33.17773	NORMAL	
8	17	10	11562307200	50	50 - 54	61.5	164.0	74	22.86585	NORMAL	
9	18	10	11538028800	51	50 - 54	60.5	158.0	58	24.23490	OSTEOPENIA	
10	20	10	11332483200	57	55 - 59	64.0	149.0	61	28.82753	OSTEOPENIA	
11	21	10	11631945600	48	45 - 49	70.3	160.0	67	27.46094	OSTEOPENIA	
12	22	10	11425536000	55	55 - 59	74.4	160.0	68	29.06250	OSTEOPENIA	
13	23	10	11553235200	50	50 - 54	55.5	154.5	73	23.25070	OSTEOPENIA	
14	24	10	11367302400	56	55 - 59	89.0	166.0	61	32.29787	OSTEOPENIA	
15	25	10	11585635200	49	45 - 49	50.6	157.0	68	20.52822	OSTEOPENIA	
16	26	10	11572156800	50	50 - 54	71.4	152.0	74	30.90374	NORMAL	
17	27	10	11590992000	49	45 - 49	78.0	157.0	62	31.64429	OSTEOPENIA	
18	28	10	11293516800	58	55 - 59	72.0	162.0	65	27.43484	OSTEOPENIA	
19	29	10	11215238400	61	60 - 64	68.0	155.5	65	28.12212	OSTEOPENIA	
20	30	10	11405664000	55	55 - 59	75.0	161.0	92	28.93407	NORMAL	
21	31	10	11633155200	48	45 - 49	66.5	153.0	11	28.40788	OSTEOPOROSIS	
22	32	10	11287728000	59	55 - 59	101.0	156.0	82	41.50230	NORMAL	
23	34	10	10992758400	68	65 - 69	66.5	145.0	57	31.62901	OSTEOPENIA	
24	35	10	10909382400	69	65 - 69	70.0	168.0	48	24.80159	OSTEOPOROSIS	
25	36	10	11643868800	48	45 - 49	60.1	153.0	86	25.67389	NORMAL	
26	37	10	11551420800	50	50 - 54	67.0	159.0	105	26.50212	NORMAL	
27	38	10	11043907200	66	65 - 69	67.0	144.0	79	32.31096	NORMAL	
28	39	10	10948089600	69	65 - 69	70.5	148.5	40	31.96953	OSTEOPOROSIS	
29	40	10	11051251200	66	65 - 69	66.5	147.0	48	30.77421	OSTEOPOROSIS	
30	41	10	11333692800	57	55 - 59	58.5	142.0	80	29.01210	NORMAL	

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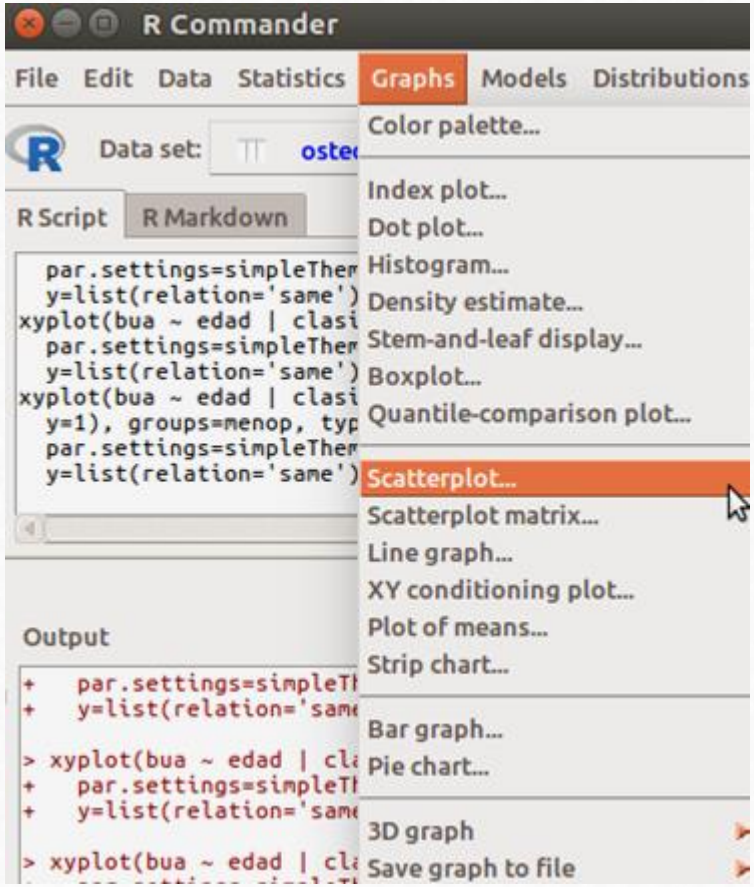
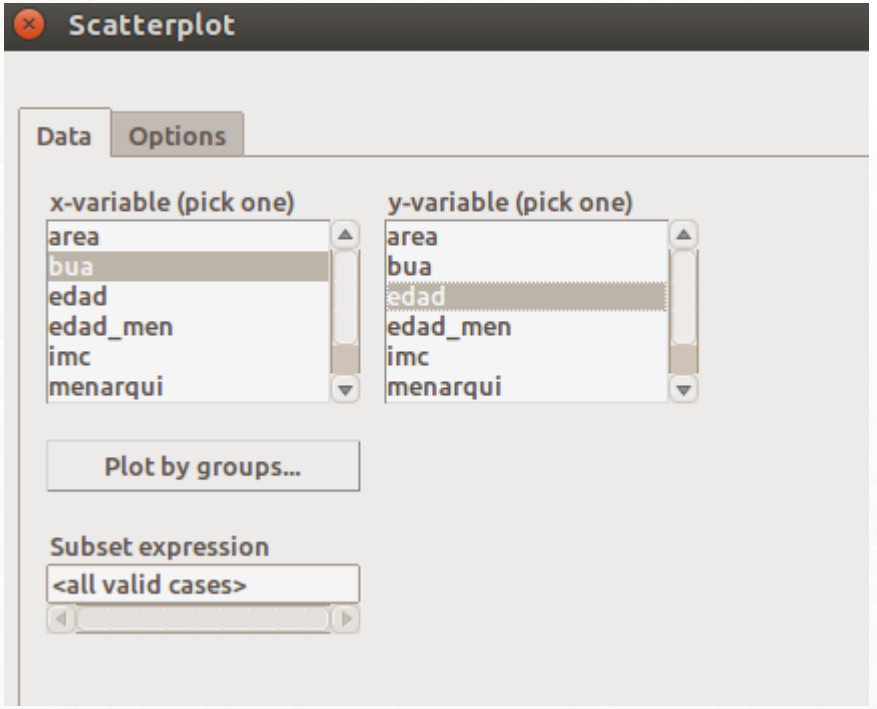
The way to study the relation will depend on the variable types:

- Two **quantitatives** variables





2. Bivariate analysis

2.3 Quantitative versus Quantitative

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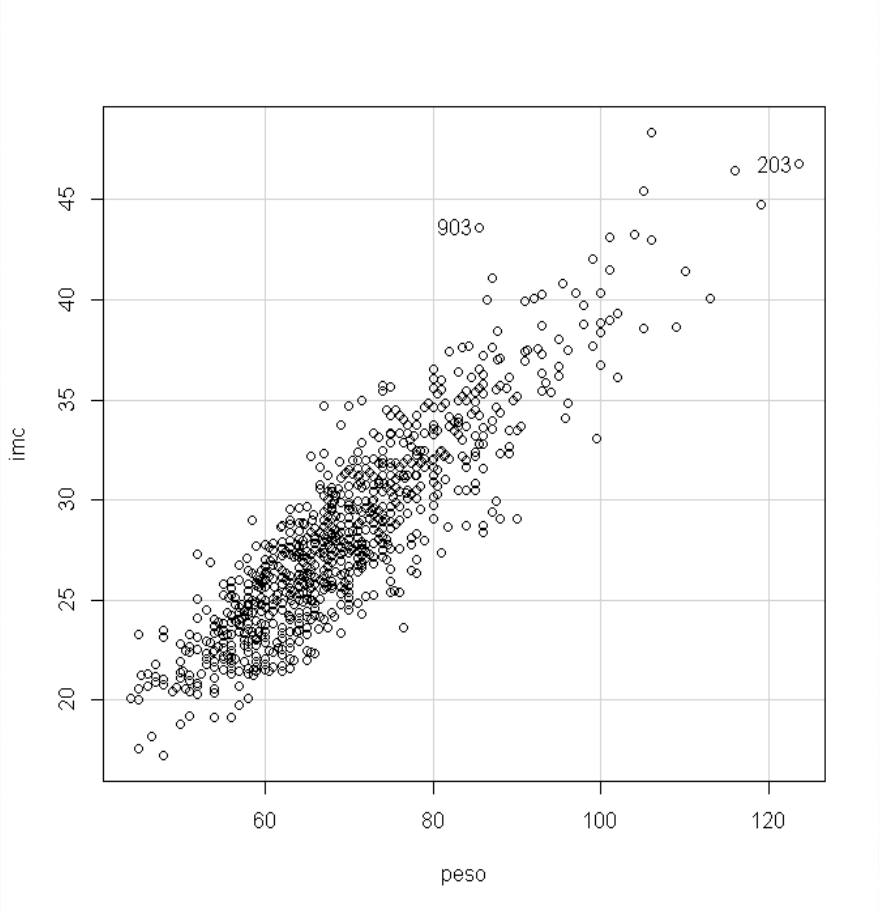
The way to study the relation will depend on the variable types:



2. Bivariate analysis

2.3 Quantitative versus Quantitative

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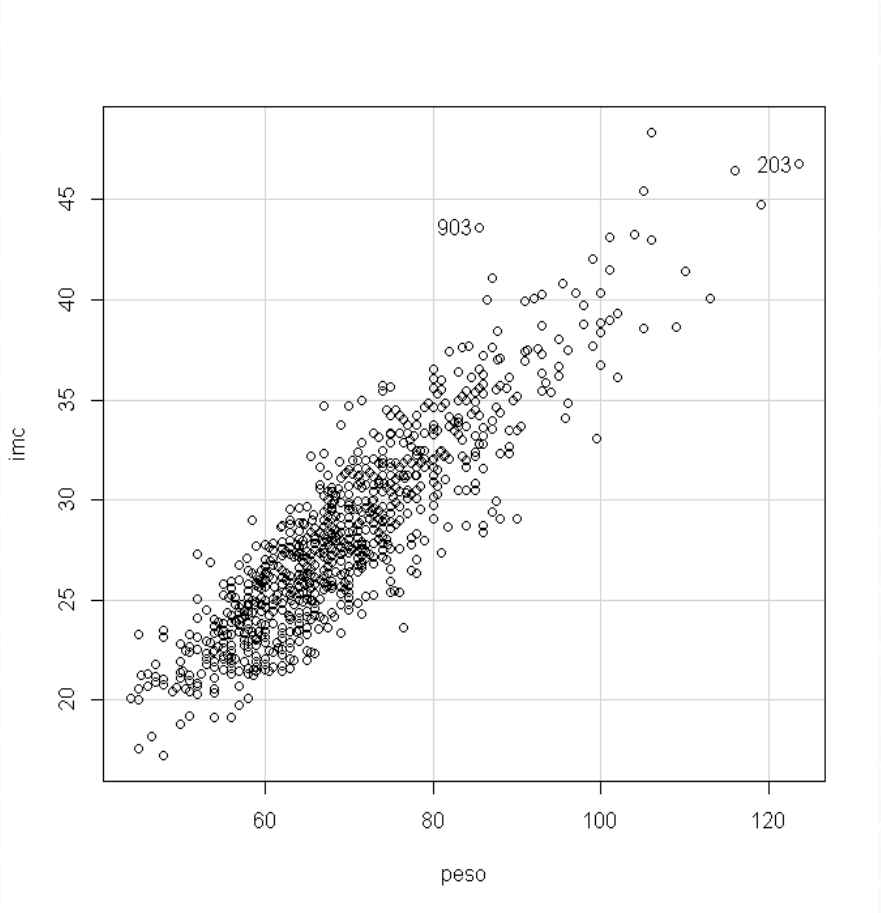
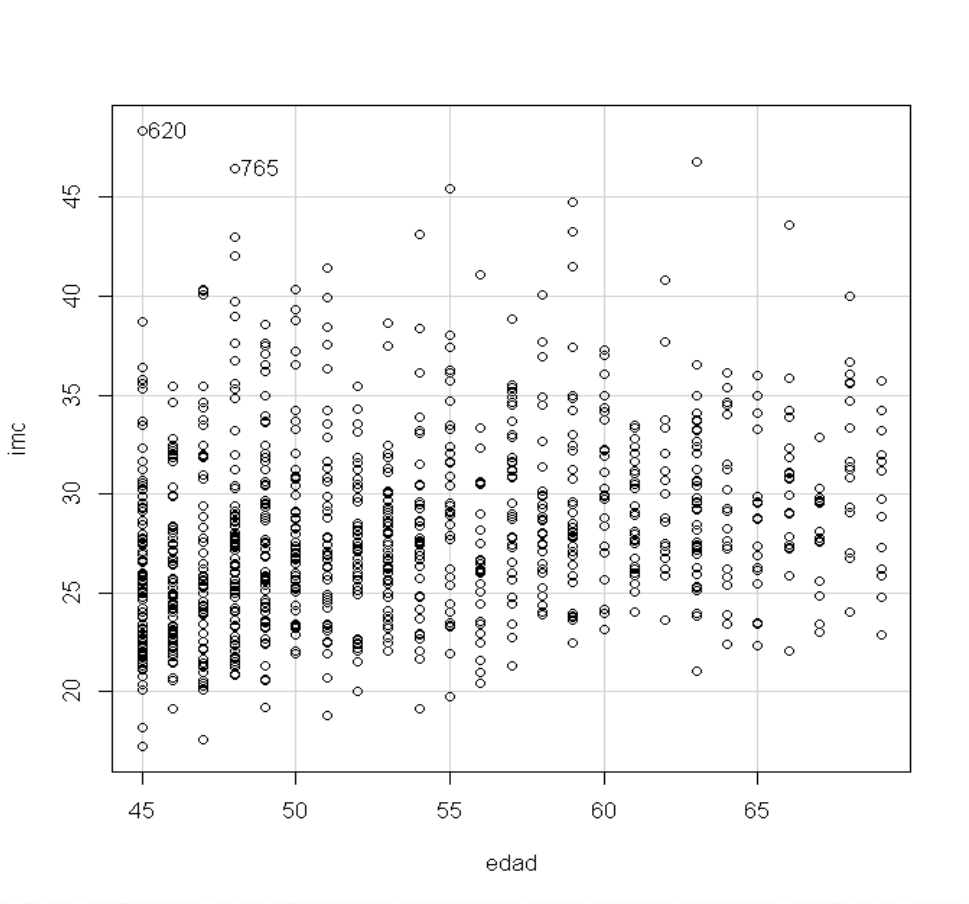
The way to study the relation will depend on the variable types:





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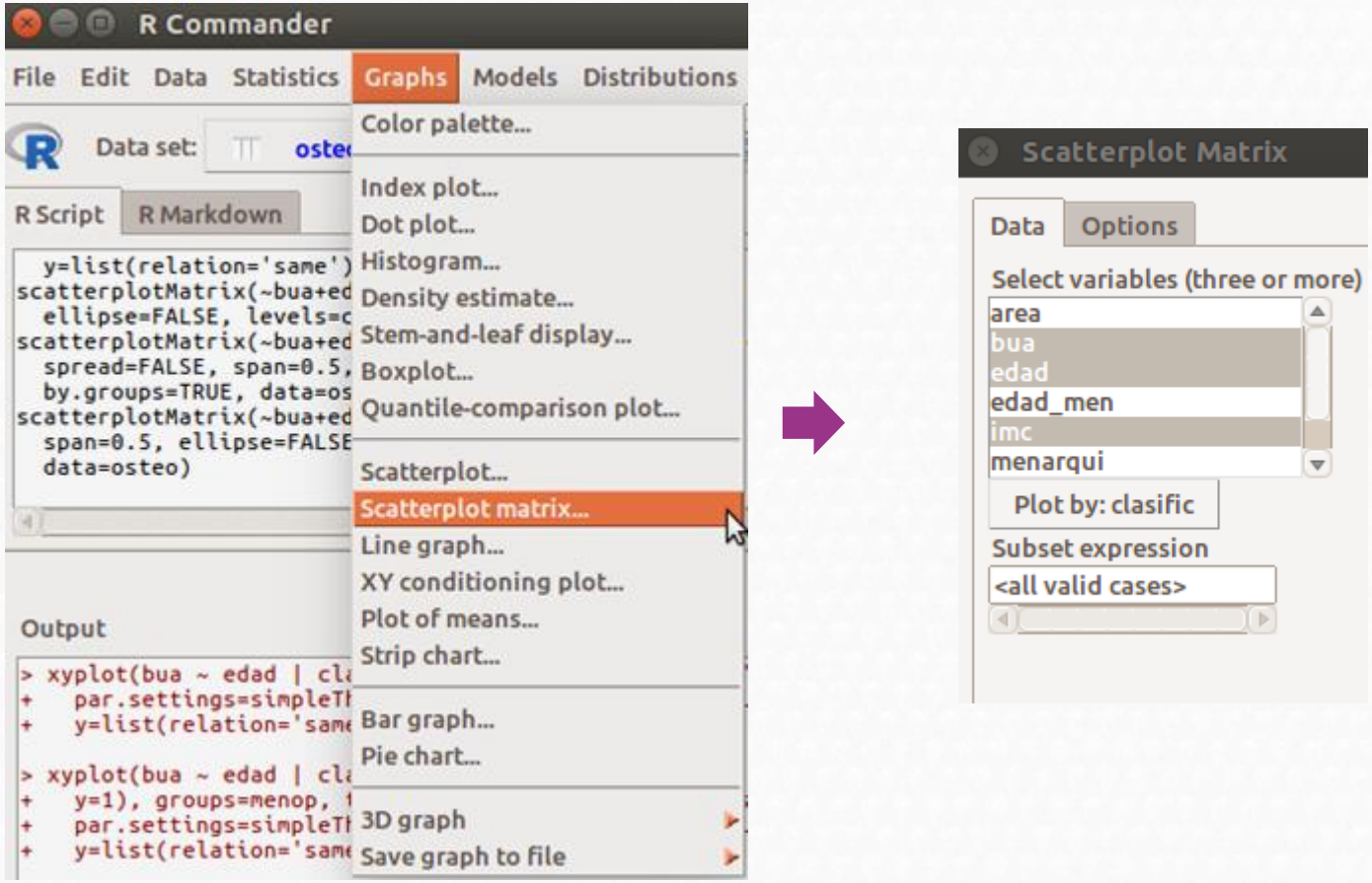
The way to study the relation will depend on the variable types:

- Two **quantitatives** variables:



2. Bivari
2.3

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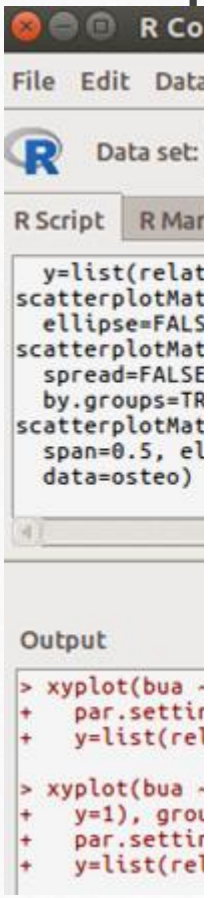
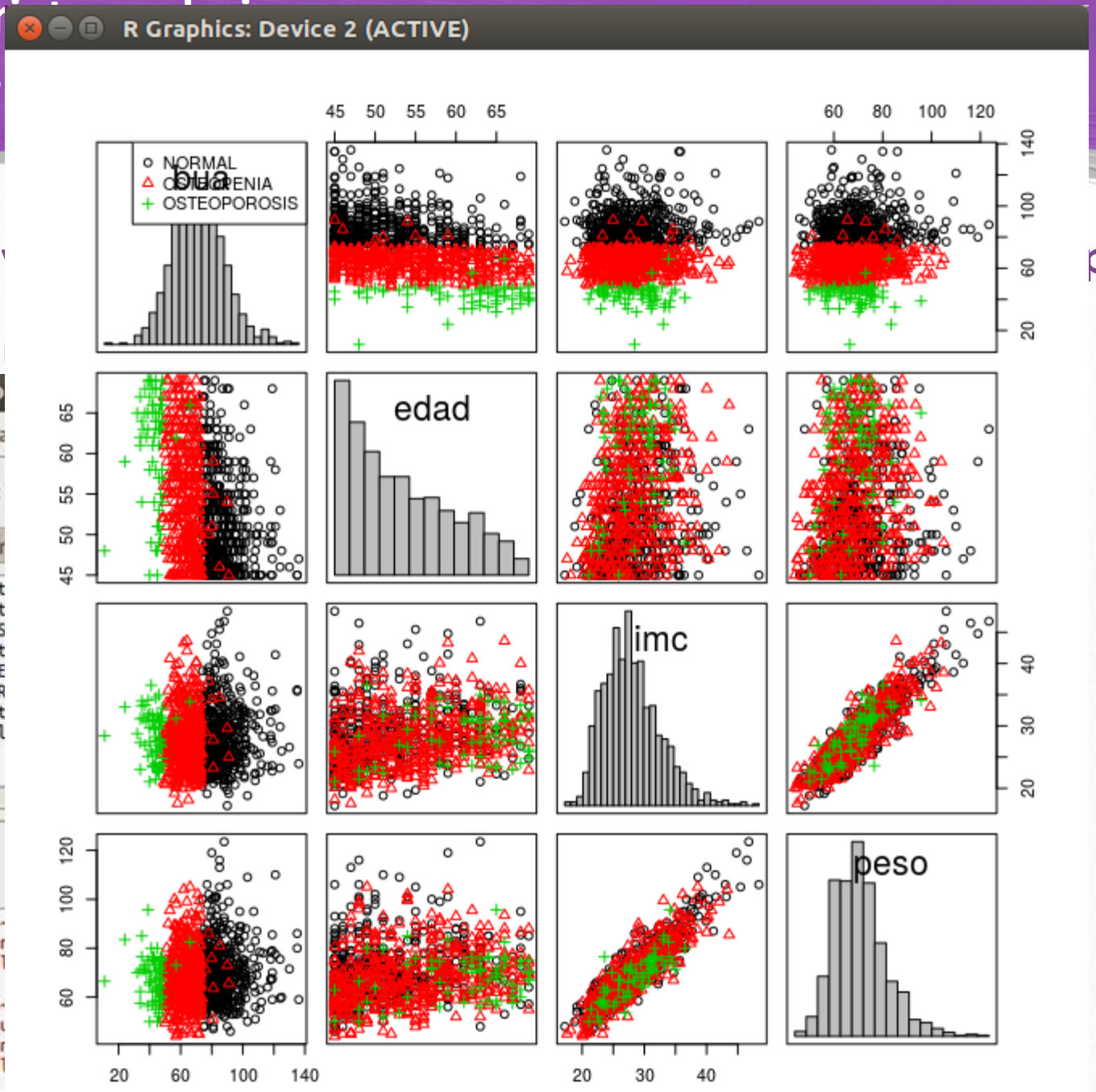
The wa **pes:**

- Two **q**





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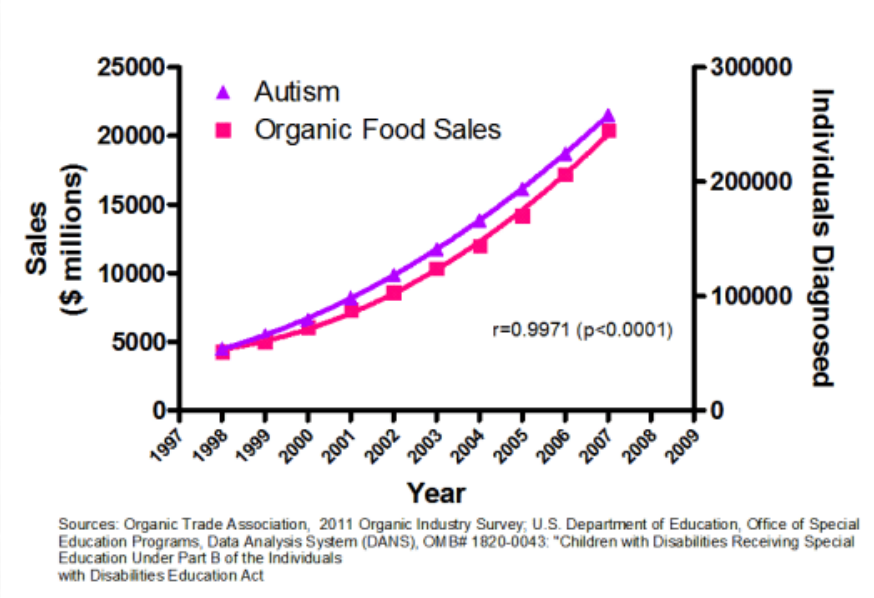
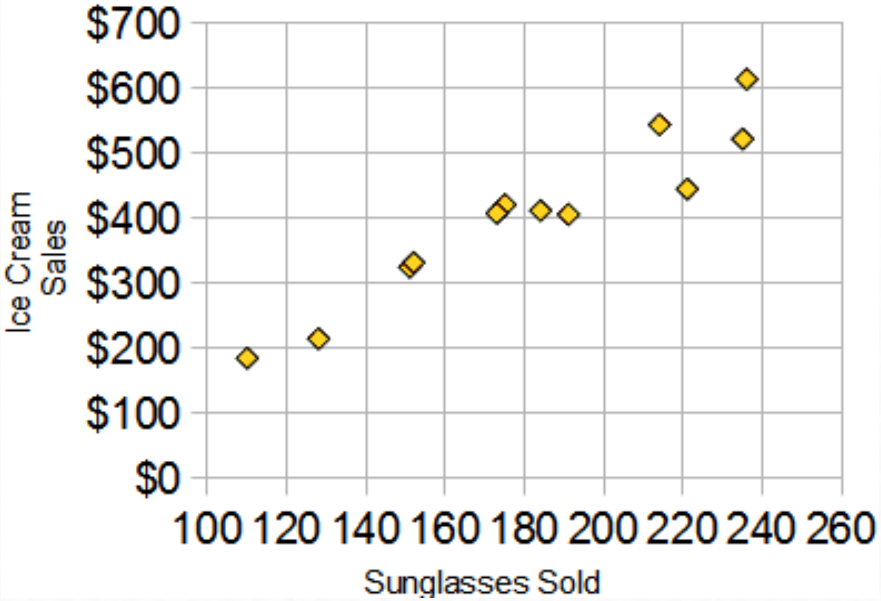
Main characteristics of correlation analysis:

- Correlation analysis allow:
  - Study the **way** of relation between the two variables
  - **Quantify** the intensity of relation
- Correlation is **not causation** ➡ one thing does not causes the other
- In the correlation analysis, the two variables have the **same weigh**
- The **correlation coefficient** measures the strength of the relation

Main characteristics of correlation analysis:

Correlation is not causation





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Pearson correlation coefficient

- It is represented by letter “r”. It has no dimensions (no units)
- Values go from **-1** to **+1**
  - **r=0** indicates no linear relation between the variables
  - **r>0** indicates direct relation between the variables
  - **r<0** indicates indirect relation between the variables
  - **r=1/-1** indicates a perfect relation between the variables

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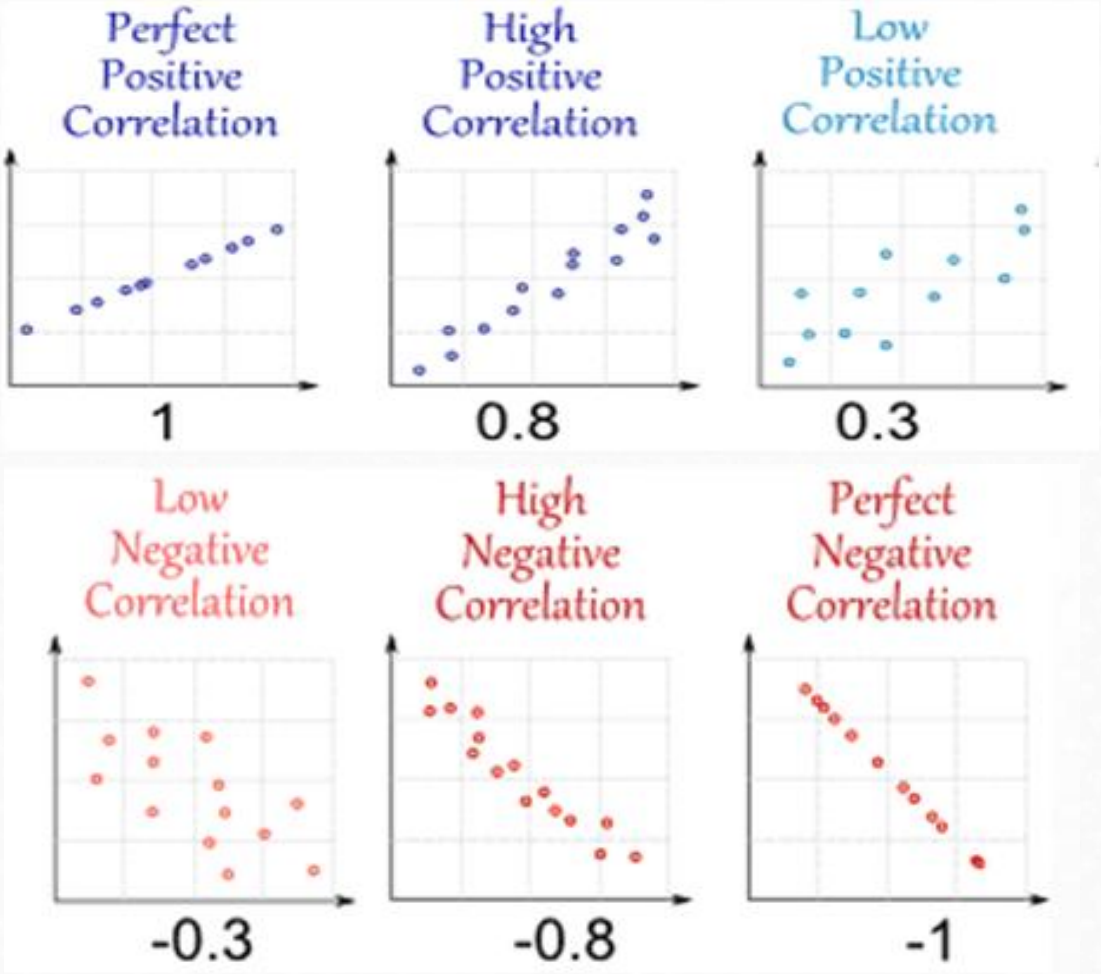
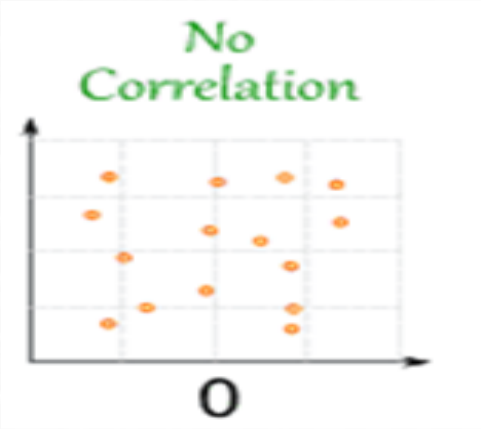
Pearson correlation coefficient. Examples





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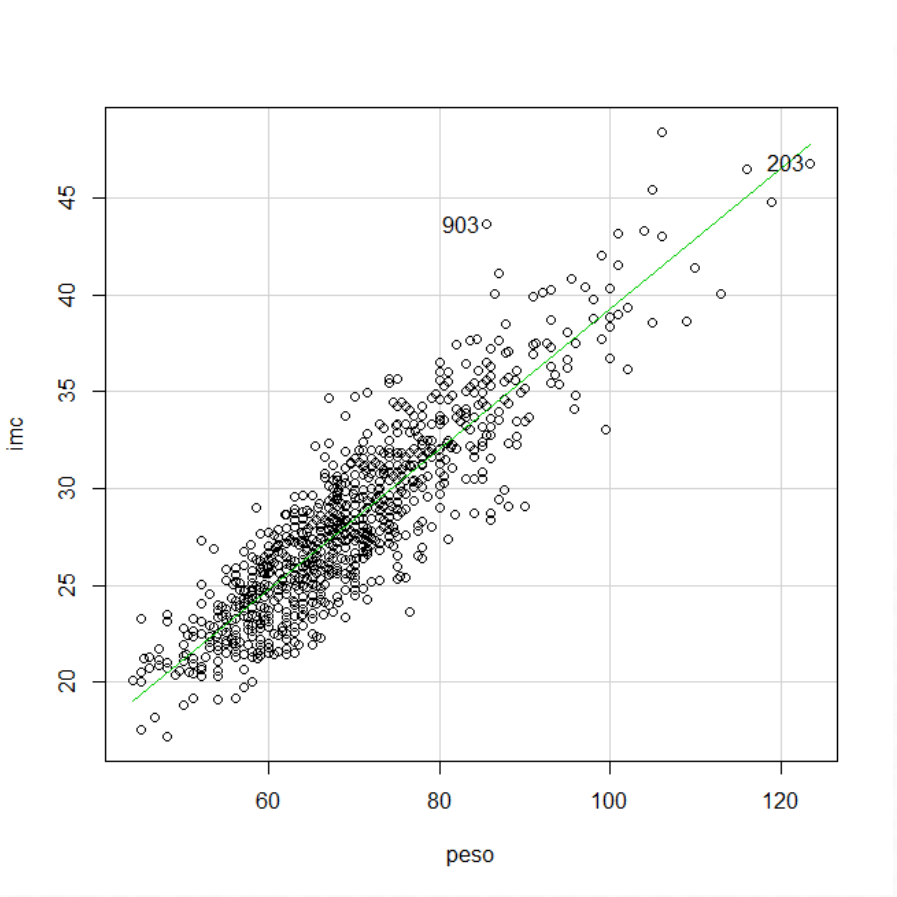
Study the relationship between *peso* and *body mass index (imc)*:

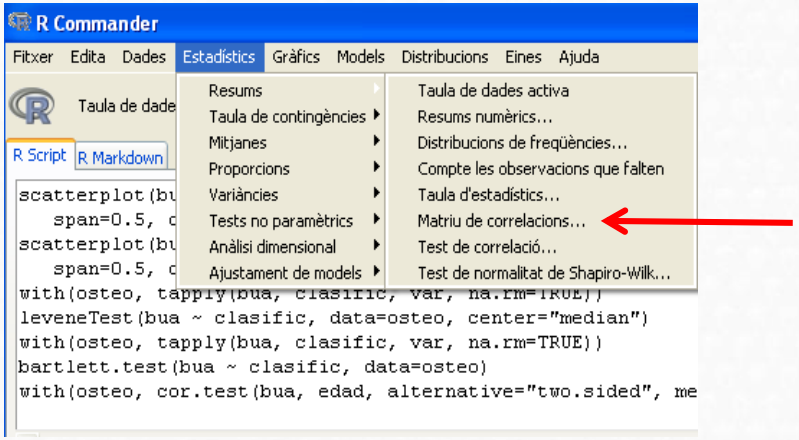
```
             imc       peso
imc   1.0000000 0.8927967
peso  0.8927967 1.0000000
```

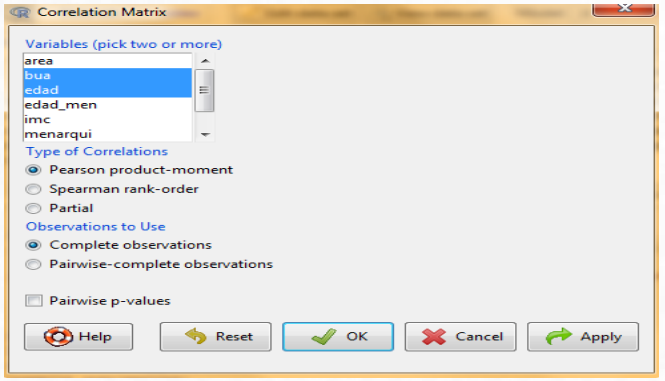


3. Correlation
2. Types of correlation

Pearson correlation coefficient. How to in R-commander?

Bone density and **age** are correlated?

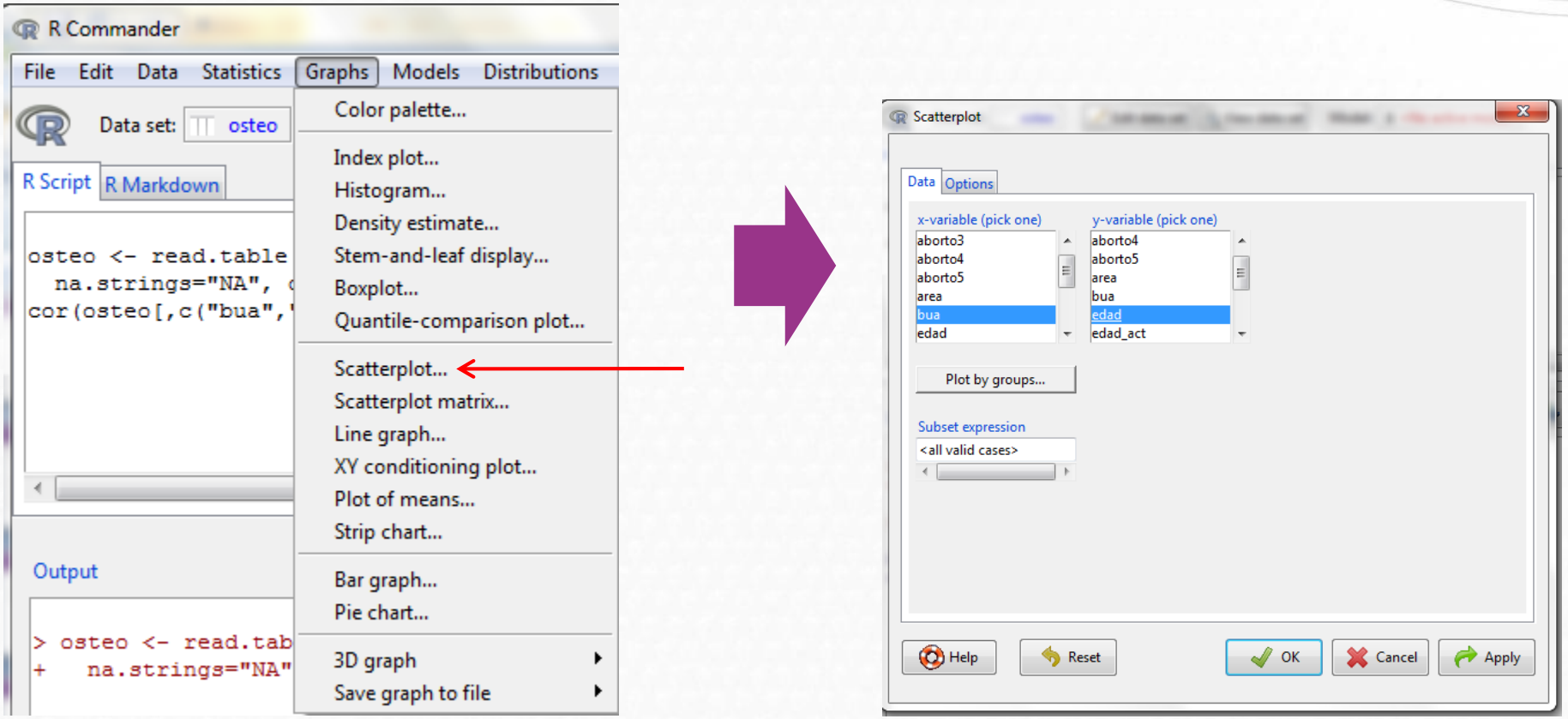




Don't forget to look the graphic!!

```
> cor(osteo[,c("bua","edad")], use="complete")
             bua       edad
bua    1.0000000 -0.3601883
edad -0.3601883  1.0000000
```

3. Correlation
2. Types of correlation



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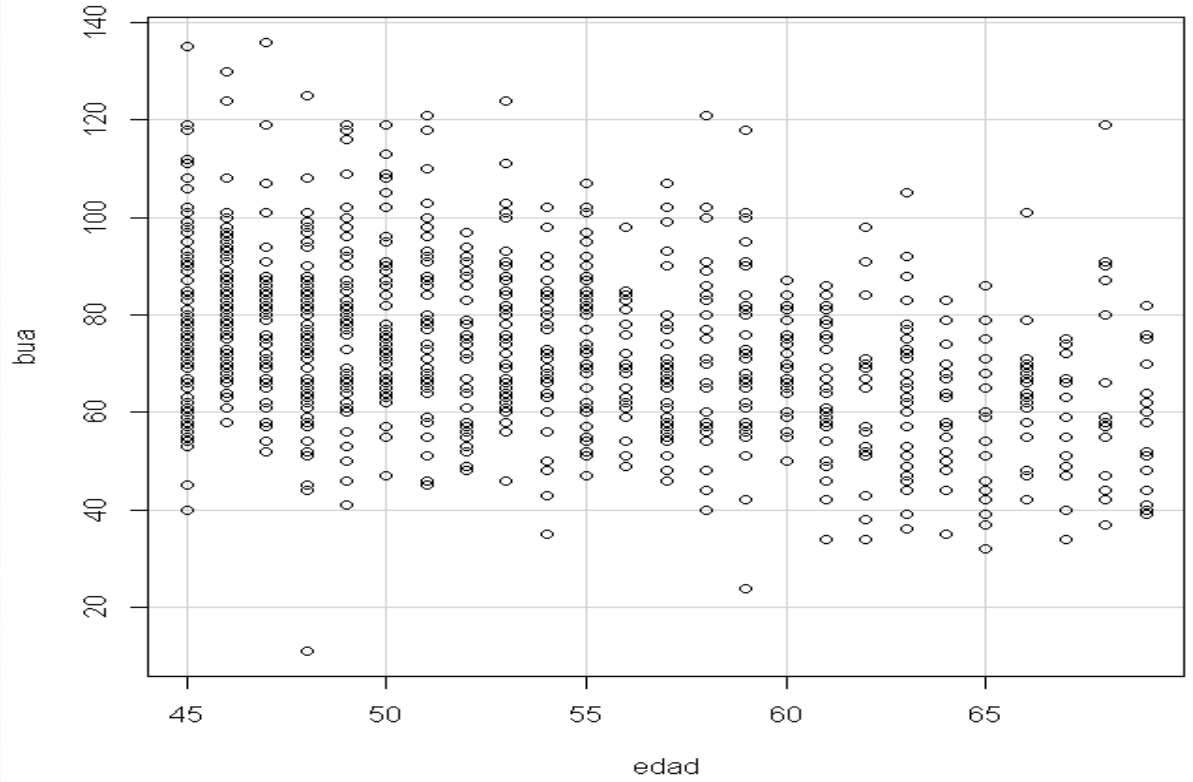
Pearson correlation coefficient. How to in R-commander?



Pearson correlation coefficient. How to in R-commander?

Exercise 1. Do you think that exists a relationship between *peso* and *talla*? What type of relationship? Show a scatterplot of the values.

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Non Parametric correlation: Spearman correlation coefficient

- Pearson correlation coefficient is severely affected by outliers and if the relation is not lineal

  ⬇

  Better to use Spearman correlation coefficient (use the ranks between the numbers instead the values) to calculate the correlation coefficient

- Evaluates the monotonic relationship between the variables (not the **linear** relationship as Pearson does).

  ⬇

  The variables tend to change together but not necessarily at a constant rate

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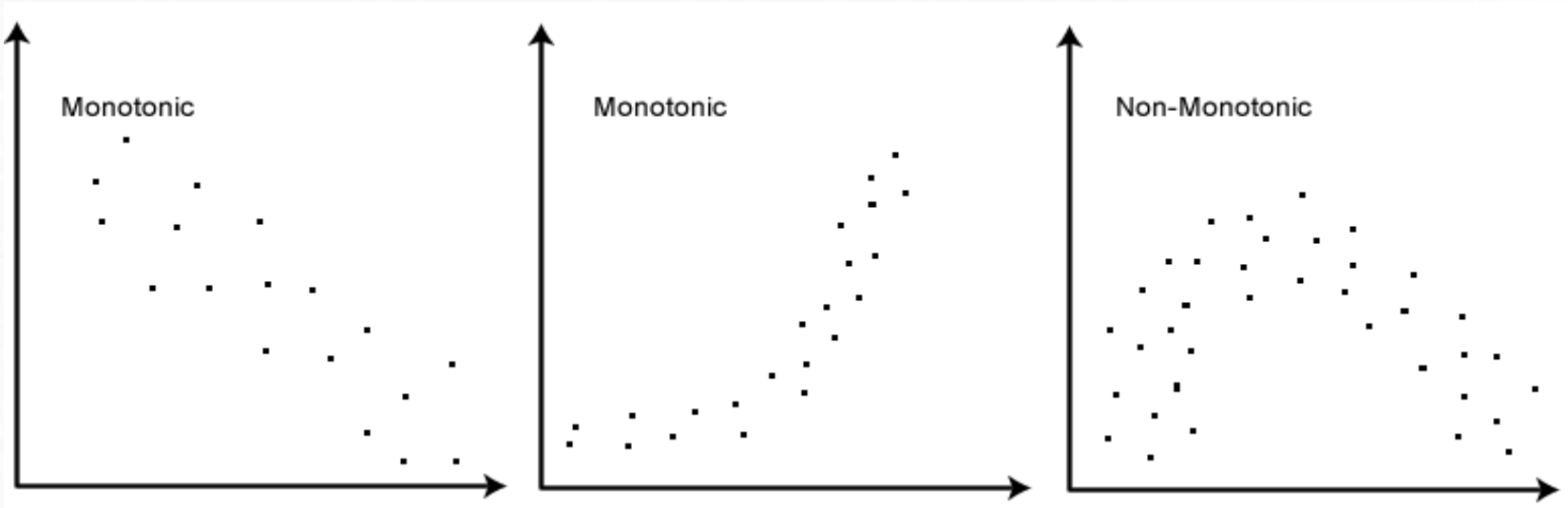
Non Parametric correlation: Spearman correlation coefficient



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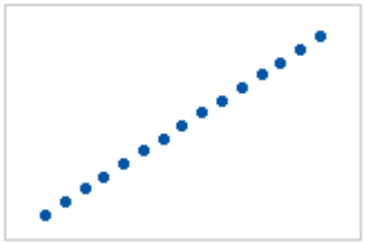
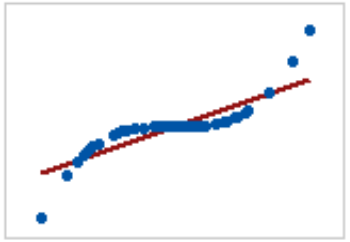
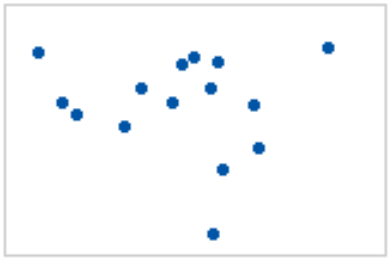
Comparison of Pearson and Spearman coefficients.



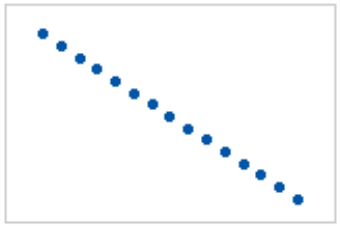
Pearson = +1, Spearman = +1



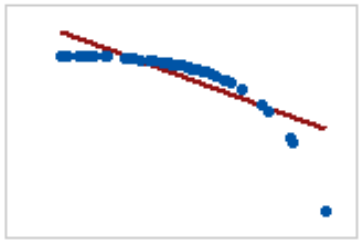
Pearson = +0.851, Spearman = +1



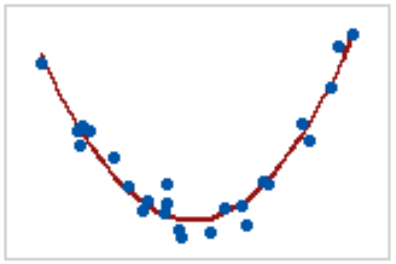
Pearson = -0.093, Spearman = -0.093



Pearson = -1, Spearman = -1



Pearson = -0.799, Spearman = -1

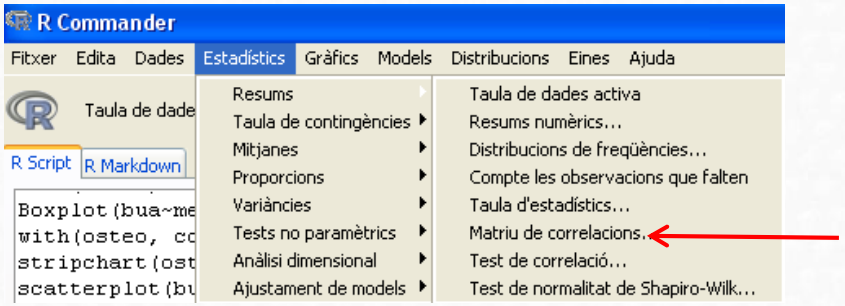


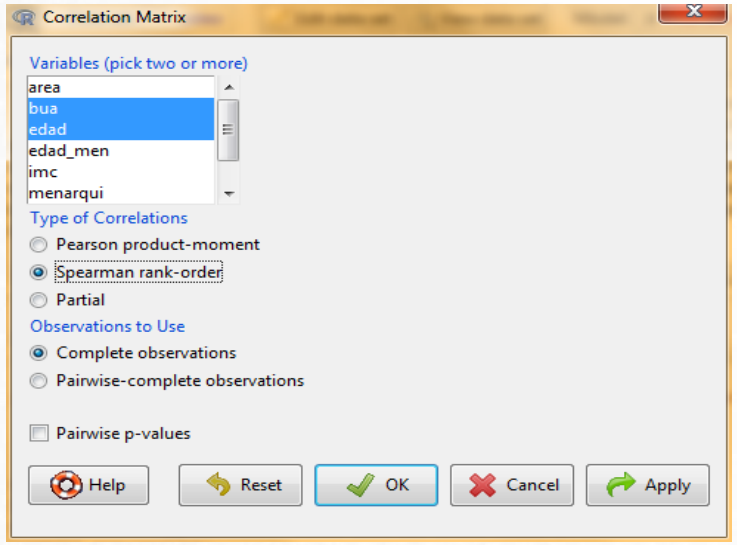
Coefficient of 0

Always examine a scatterplot to determine the form of the relationship

3. Correlation
2. Types of correlation

Spearman correlation coefficient. How to in R-commander?






```
> cor(osteo[,c("bua","edad")], method="spearman", use="complete")
             bua        edad
bua    1.0000000 -0.3540295
edad -0.3540295  1.0000000
```

Exercise 2. An hypothetic study, published last year that exists a relation between ***age*** and ***systolic blood pressure (sbp)*****?** Do you think is it true? Show a scatterplot of the values? If not, find another variable in the dataset that has a good correlation with ***systolic blood pressure***.

Use dataset Framingham250.csv