STATISTICAL ANALYSIS ON EGYPTIAN SKULL MEASUREMENTS THROUGH THE CENTURIES

By: Diego A. Rodriguez Moreno

Contents:

ABOUT THE DATASET

Egyptian Skulls

There are five samples of 30 skulls from each of the early predynastic period (circa 4000 BC), the late predynastic period (circa 3300 BC), the 12th and 13th Dynasties (circa 1850 BC), the Ptolemaic period (circa 200 BC), and the Roman period (circa AD 150). The measurements were made on male skulls near Thebes, Egypt.
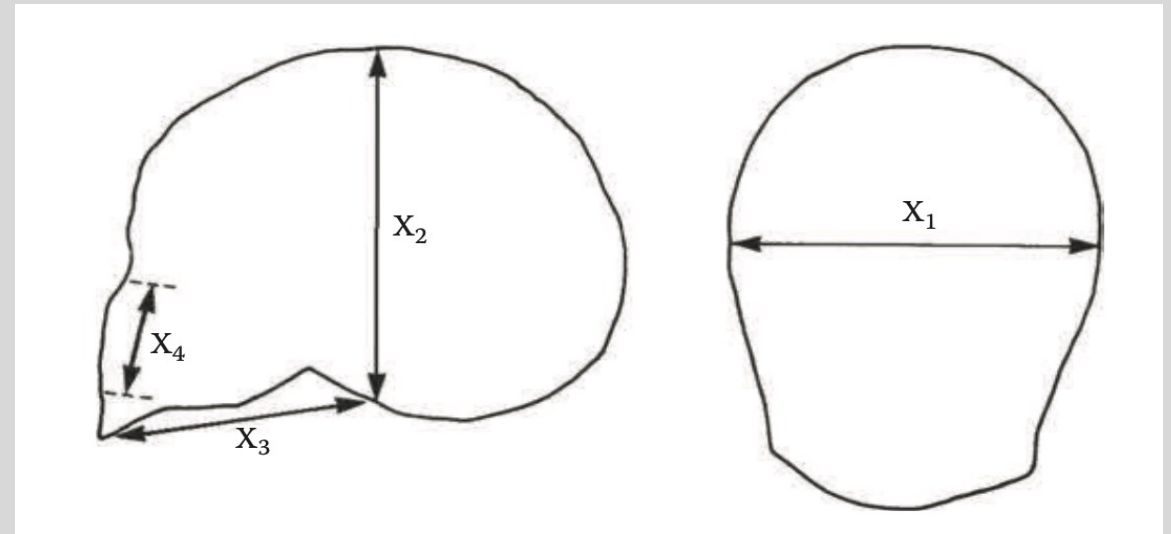
X1 = maximum breadth,
X2 = Basi bregmatic height,
X3 = Basi alveolar length,
X4 = nasal height, all in millimeters.

	Early predynastic				Late predynastic				12th and 13th Dynasties				Ptolemaic period				Roman period			
Skull	X_1	X_2	X_3	X_4	X_1	X_2	X_3	X_4	X_1	X_2	X_3	X_4	X_1	X_2	X_3	X_4	X_1	X_2	X_3	X_4
1	131	138	89	49	124	138	101	48	137	141	96	52	137	134	107	54	137	123	91	50
2	125	131	92	48	133	134	97	48	129	133	93	47	141	128	95	53	136	131	95	49
3	131	132	99	50	138	134	98	45	132	138	87	48	141	130	87	49	128	126	91	57
4	119	132	96	44	148	129	104	51	130	134	106	50	135	131	99	51	130	134	92	52
5	136	143	100	54	126	124	95	45	134	134	96	45	133	120	91	46	138	127	86	47

SAMPLE DATA

Sample Statistics

◦ Mean

```
              Group.1 Max.breadth Basibreg.ht Basial.ht Nasal.ht
1   early.predynastic     131.3667    133.6000   99.16667 50.53333
2    late.predynastic     132.3667    132.7000   99.06667 50.23333
3 m12th.13th.dynasty      134.4667    133.8000   96.03333 50.56667
4           Ptolemaic     135.5000    132.3000   94.53333 51.96667
5               Roman     136.1667    130.3333   93.50000 51.36667
```

◦ Pooled Covariance

```
             Max.breadth Basibreg.ht    Basial.ht  Nasal.ht
Max.breadth  21.11080460  0.03678161   0.07908046  2.008966
Basibreg.ht   0.03678161 23.48459770   5.20000000  2.845057
Basial.ht     0.07908046  5.20000000  24.17908046  1.133333
Nasal.ht      2.00896552  2.84505747   1.13333333 10.152644
```

METHODOLOGY OF THE ANALYSIS

Hypotheses

H0: The mean values for the four variables measured on the Egyptian skulls have not varied over time.

H1: The mean values for the four variables measured on the Egyptian skulls have varied over time.

Statistical Tests on The Egyptian Skulls Dataset

Levene's to test the covariance matrices among five temporal groups.

ANOVA to test the individual difference in means among five temporal periods.

MANOVA to test all the differences in the mean vector across the five temporal periods.

Distance matrix to visualize any change over the five temporal periods.

Mantel's test to test the correlation between the Distance matrices and the temporal matrix of the Egyptian skulls.

Tools and Resources

- All tests are performed using R software.

- The biotools library is required for some of these tests.

Levene's Test

- HO: There is no significant difference in the covariance matrices among the five temporal groups.

- H1: There is significant difference in the covariance matrices among the five temporal groups.

```
*Levene's test on mean deviations:
          Df  Pillai approx F num Df den Df Pr(>F)
group      4 0.09676  0.89863      16    580 0.5709
Residuals 145
```

We do not reject HO. We conclude that there is no significant difference in the covariance matrices among the five temporal groups.

One Way ANOVA tests

Test Results		
Skull Part	F Value	P value
maximum breadth	5.955	0.000183
Basi bregmatic height	2.447	0.049
Basi alveolar length	8.306	0.000004
nasal height	1.507	0.203

- HO: There is no significant difference in the mean vectors among the five temporal groups.

- H1: There is significant difference in the mean vectors among the five temporal groups.

- Based on our results, we reject H0 in all but one variable; we conclude that there is significant different in the five mean vectors across the five time periods.

MANOVA TEST

Test Results		
MANOVA Test	F Value	P Value
Wilks	3.9009	0.0000007
Roy	15.41	0.00000000001
Hotelling	4.231	0.00000008

◦ H0: There is not a highly significant difference in the five mean vectors across the five time periods.

◦ H1: There is a highly significant difference in the five mean vectors across the five time periods.

◦ From our test, we reject H0; We conclude that there is a highly significant difference in the five mean vectors across the five time periods.

Distance Matrix

```
> round(DistEuclid$D, 3)
                 early.predynastic late.predynastic m12th.13th.dynasty Ptolemaic Roman
early.predynastic            0.000            1.382              4.412     6.504 8.156
late.predynastic             1.382            0.000              3.864     5.791 7.233
m12th.13th.dynasty           4.412            3.864              0.000     2.744 4.687
Ptolemaic                    6.504            5.791              2.744     0.000 2.396
Roman                        8.156            7.233              4.687     2.396 0.000
> round(DistPenrose$D, 3)
                 early.predynastic late.predynastic m12th.13th.dynasty Ptolemaic Roman
early.predynastic            0.000            0.023              0.216     0.493 0.736
late.predynastic             0.023            0.000              0.163     0.404 0.583
m12th.13th.dynasty           0.216            0.163              0.000     0.108 0.244
Ptolemaic                    0.493            0.404              0.108     0.000 0.066
Roman                        0.736            0.583              0.244     0.066 0.000
> round(DistMahalan$D, 3)
                 early.predynastic late.predynastic m12th.13th.dynasty Ptolemaic Roman
early.predynastic            0.000            0.091              0.903     1.881 2.697
late.predynastic             0.091            0.000              0.729     1.594 2.176
m12th.13th.dynasty           0.903            0.729              0.000     0.443 0.911
Ptolemaic                    1.881            1.594              0.443     0.000 0.219
Roman                        2.697            2.176              0.911     0.219 0.000
```

- To visualize change over time, we created a distance matrix that shows the Euclidean, Penrose and Mahalanobis distance, respectively.

- The matrix displays the change in variance mean values over time.

- we can easily see that the mean skull measurements get progressively further apart in time, with the largest distance occurring between the most modern and most ancient time period.

Mantel's Test

- H0: There is no positive correlation between the temporal distance matrix and the distance matrix.

- H1: There is positive correlation between the temporal distance matrix and the distance matrix.

- From our test results, we reject H0 in all instances; we conclude there is positive correlation between the temporal distance and distance matrices on the Egyptian skulls.

- That is, as time goes on, the distance matrices become more dissimilar.

Test Results		
Mantel's Test	Correlation Value	P Value
Euclidean Distance	r= 0.957214	0.021
Penrose Distance	r= 0.954344	0.165
Mahalanobis Distance	r= 0.96415	0.0195

TO HELP US SEE THE CORRELATION, THE GRAPH DISPLAYS A CLEAR POSITIVE CORRELATION WITH ALL THE DISTANCE AS TEMPORAL DISTANCE GOES ON.
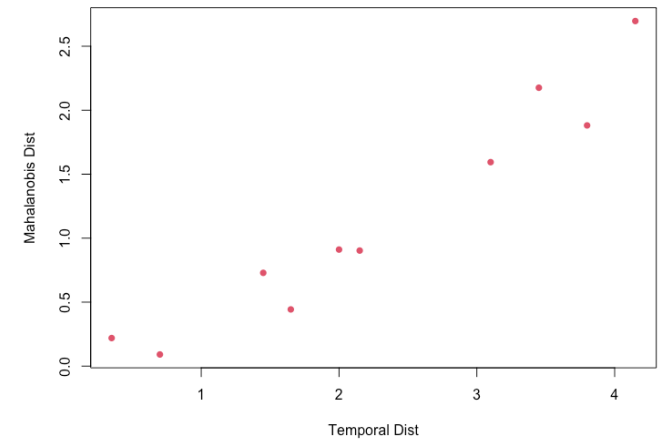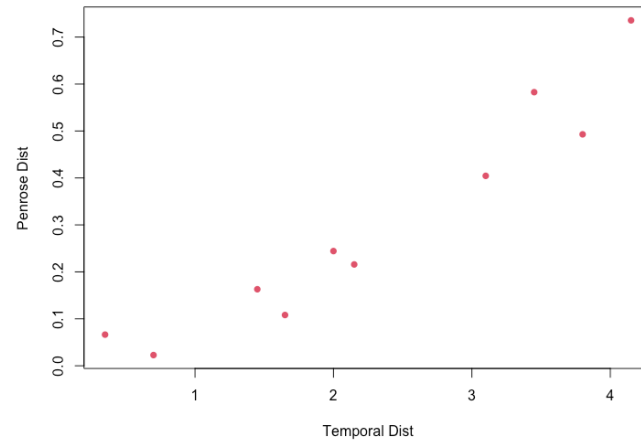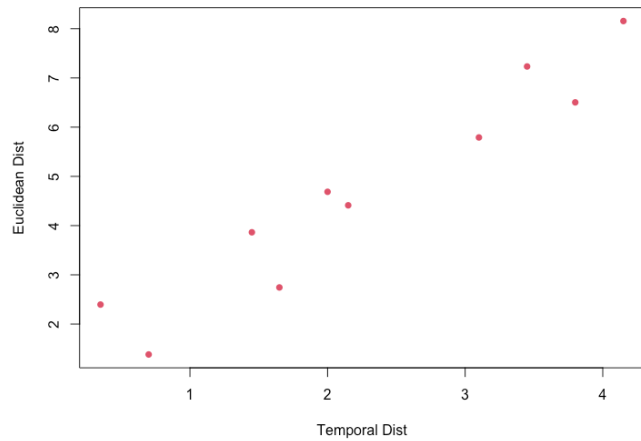
CONCLUSIONS AND POSSIBLE MISTAKES.
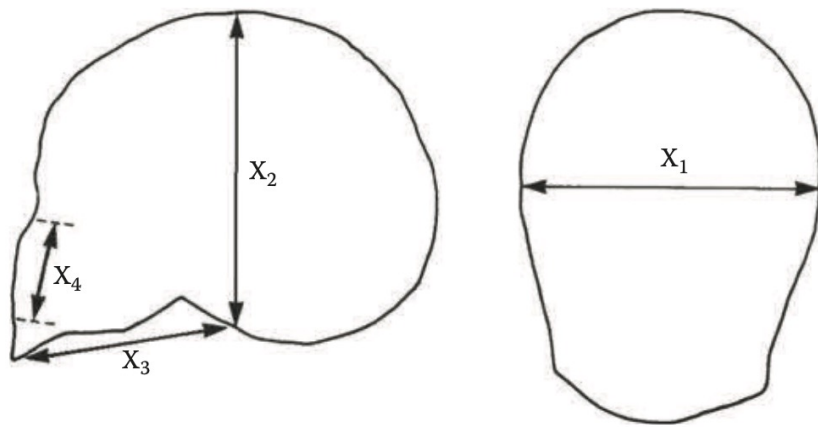
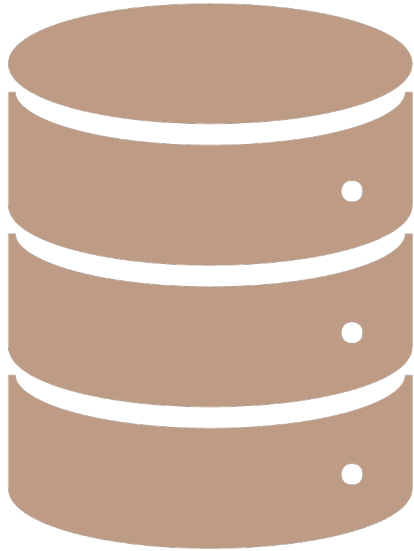Based on the results from multiple statistical tests, we can reject H0; we conclude that over time, the mean values from skull measurements in Thebes, Egypt have changed.

This change can be result of many reasons. Interbreeding, natural selection, immigration could be some of those reasons.

We could be making a Type 1 error since we are rejecting the null hypothesis.

RESOURCES

Dataset:
https://www.picostat.com/dataset/r-dataset-package-hsaur-skulls