```
OUTPUT ACTIVATE TukeyHSDOutput.
1584  0 M>  OUTPUT ACTIVATE TukeyHSDOutput.

1585  0 M>
* Create output folders before running procedures.
1586  0 M>  * Create output folders before running procedures.
BEGIN PROGRAM Python3.
1587  0 M>  BEGIN PROGRAM Python3.
import os
base = r'D:\DATA ANALYSIS\F Post Hoc Tests\Tukey HSD Test'
folders = [
    os.path.join(base, 'SPSS_Output'),
    os.path.join(base, 'SPSS_Output', 'charts'),
    os.path.join(base, 'SPSS_Output', 'pdf'),
    os.path.join(base, 'SPSS_Output', 'tables')
]
for folder in folders:
    os.makedirs(folder, exist_ok=True)
with open(os.path.join(base, 'SPSS_Output', 'tukey_output_folder_check.txt'),
'w', encoding='utf-8') as f:
    f.write('SPSS output folders were created successfully.\n')
END PROGRAM.

1600  0 M>
GET DATA
1601  0 M>  GET DATA
  /TYPE=TXT
1602  0 M>    /TYPE=TXT
  /FILE='D:\DATA ANALYSIS\F Post Hoc Tests\Tukey HSD Test\dataset.csv'
1603  0 M>    /FILE='D:\DATA ANALYSIS\F Post Hoc Tests\Tukey HSD Test\dataset.
csv'
  /ENCODING='UTF8'
1604  0 M>    /ENCODING='UTF8'
  /DELCASE=LINE
1605  0 M>    /DELCASE=LINE
  /DELIMITERS=","
1606  0 M>    /DELIMITERS=","
  /QUALIFIER='"'
1607  0 M>    /QUALIFIER='"'
  /ARRANGEMENT=DELIMITED
1608  0 M>    /ARRANGEMENT=DELIMITED
  /FIRSTCASE=2
```

```
1609  0 M>    /FIRSTCASE=2
  /VARIABLES=
1610  0 M>    /VARIABLES=
    school A10
1611  0 M>      school A10
    sex A10
1612  0 M>      sex A10
    age F8.2
1613  0 M>      age F8.2
    address A10
1614  0 M>      address A10
    famsize A10
1615  0 M>      famsize A10
    Pstatus A10
1616  0 M>      Pstatus A10
    Medu F8.2
1617  0 M>      Medu F8.2
    Fedu F8.2
1618  0 M>      Fedu F8.2
    Mjob A30
1619  0 M>      Mjob A30
    Fjob A30
1620  0 M>      Fjob A30
    reason A30
1621  0 M>      reason A30
    guardian A30
1622  0 M>      guardian A30
    traveltime F8.2
1623  0 M>      traveltime F8.2
    studytime F8.2
1624  0 M>      studytime F8.2
    failures F8.2
1625  0 M>      failures F8.2
    schoolsup A10
1626  0 M>      schoolsup A10
    famsup A10
1627  0 M>      famsup A10
    paid A10
1628  0 M>      paid A10
    activities A10
1629  0 M>      activities A10
    nursery A10
```

```
1630  0 M>      nursery A10
    higher A10
1631  0 M>      higher A10
    internet A10
1632  0 M>      internet A10
    romantic A10
1633  0 M>      romantic A10
    famrel F8.2
1634  0 M>      famrel F8.2
    freetime F8.2
1635  0 M>      freetime F8.2
    goout F8.2
1636  0 M>      goout F8.2
    Dalc F8.2
1637  0 M>      Dalc F8.2
    Walc F8.2
1638  0 M>      Walc F8.2
    health F8.2
1639  0 M>      health F8.2
    absences F8.2
1640  0 M>      absences F8.2
    G1 F8.2
1641  0 M>      G1 F8.2
    G2 F8.2
1642  0 M>      G2 F8.2
    G3 F8.2.
1643  0 M>      G3 F8.2.
CACHE.
1644  0 M>  CACHE.
EXECUTE.
1645  0 M>  EXECUTE.
DATASET NAME TukeyHSDData WINDOW=FRONT.
1646  0 M>  DATASET NAME TukeyHSDData WINDOW=FRONT.
```

## Dataset Name

## Notes

| | | |
|---|---|---|
| Output Created | | 24-JUN-2026 14:49:31 |
| Comments | | |
| Input | Data | D:\DATA ANALYSIS\F Post Hoc Tests\Tukey HSD Test\dataset.csv |
| | Filter | <none> |
| | Weight | <none> |
| | Split File | <none> |
| | N of Rows in Working Data File | 649 |
| Syntax | | DATASET NAME TukeyHSDData WINDOW=FRONT. |
| Resources | Processor Time | 00:00:00.00 |
| | Elapsed Time | 00:00:00.00 |

## Warnings

The active dataset will replace the existing dataset named TukeyHSDData.

```
1647  0 M>
FORMATS studytime (F8.0) G3 (F8.2).
1648  0 M>  FORMATS studytime (F8.0) G3 (F8.2).
VARIABLE LABELS
1649  0 M>  VARIABLE LABELS
  G3 'Final grade / dependent variable'
1650  0 M>    G3 'Final grade / dependent variable'
  studytime 'Study time group / Tukey HSD factor'.
1651  0 M>    studytime 'Study time group / Tukey HSD factor'.
VALUE LABELS studytime
1652  0 M>  VALUE LABELS studytime
  1 'Studytime 1: <2 hours'
1653  0 M>    1 'Studytime 1: <2 hours'
  2 'Studytime 2: 2 to 5 hours'
1654  0 M>    2 'Studytime 2: 2 to 5 hours'
  3 'Studytime 3: 5 to 10 hours'
1655  0 M>    3 'Studytime 3: 5 to 10 hours'
  4 'Studytime 4: >10 hours'.
1656  0 M>    4 'Studytime 4: >10 hours'.
EXECUTE.
```

```
1657  0 M>  EXECUTE.

1658  0 M>
TITLE 'Tukey HSD Test / Tukey-Kramer Post Hoc Analysis'.
1659  0 M>  TITLE 'Tukey HSD Test / Tukey-Kramer Post Hoc Analysis'.
```

```
SUBTITLE 'One-way ANOVA followed by Tukey HSD pairwise comparisons for G3 by s
tudytime'.
1660  0 M>  SUBTITLE 'One-way ANOVA followed by Tukey HSD pairwise comparisons
 for G3 by studytime'.

>Warning # 2004.  Command name: SUBTITLE
>The subtitle given exceeds 60 characters in length.  The first 60 characters
>will be used.
```

```
1661  0 M>
* Descriptive statistics by group.
1662  0 M>  * Descriptive statistics by group.
SORT CASES BY studytime.
1663  0 M>  SORT CASES BY studytime.
SPLIT FILE LAYERED BY studytime.
1664  0 M>  SPLIT FILE LAYERED BY studytime.
DESCRIPTIVES VARIABLES=G3
1665  0 M>  DESCRIPTIVES VARIABLES=G3
  /STATISTICS=MEAN STDDEV MIN MAX SEMEAN.
1666  0 M>    /STATISTICS=MEAN STDDEV MIN MAX SEMEAN.
```

## Descriptives

### Notes

| | | |
|---|---|---|
| Output Created | | 24-JUN-2026 14:49:31 |
| Comments | | |
| Input | Data | D:\DATA ANALYSIS\F Post Hoc Tests\Tukey HSD Test\dataset.csv |
| | Active Dataset | TukeyHSDData |
| | Filter | <none> |
| | Weight | <none> |
| | Split File | studytime |
| | N of Rows in Working Data File | 649 |
| Missing Value Handling | Definition of Missing | User defined missing values are treated as missing. |
| | Cases Used | All non-missing data are used. |
| Syntax | | DESCRIPTIVES VARIABLES=G3 /STATISTICS=MEAN STDDEV MIN MAX SEMEAN. |
| Resources | Processor Time | 00:00:00.02 |
| | Elapsed Time | 00:00:00.02 |

Tukey HSD Test / Tukey-Kramer Post Hoc Analysis
One-way ANOVA followed by Tukey HSD pairwise comparisons for

**Descriptive Statistics**

| studytime | | N Statistic | Minimum Statistic | Maximum Statistic | Mean Statistic | Mean Std. Error |
|---|---|---|---|---|---|---|
| Studytime 1: <2 hours | G3 | 212 | .00 | 18.00 | 10.8443 | .22106 |
| | Valid N (listwise) | 212 | | | | |
| Studytime 2: 2 to 5 hours | G3 | 305 | .00 | 19.00 | 12.0918 | .18570 |
| | Valid N (listwise) | 305 | | | | |
| Studytime 3: 5 to 10 hours | G3 | 97 | 8.00 | 18.00 | 13.2268 | .25405 |
| | Valid N (listwise) | 97 | | | | |
| Studytime 4: >10 hours | G3 | 35 | 6.00 | 19.00 | 13.0571 | .51358 |
| | Valid N (listwise) | 35 | | | | |

**Descriptive Statistics**

| studytime | | Std. Deviation Statistic |
|---|---|---|
| Studytime 1: <2 hours | G3 | 3.21862 |
| | Valid N (listwise) | |
| Studytime 2: 2 to 5 hours | G3 | 3.24313 |
| | Valid N (listwise) | |
| Studytime 3: 5 to 10 hours | G3 | 2.50210 |
| | Valid N (listwise) | |
| Studytime 4: >10 hours | G3 | 3.03841 |
| | Valid N (listwise) | |

```
SPLIT FILE OFF.
1667  0 M>  SPLIT FILE OFF.

1668  0 M>
* Distribution context and assumption context.
1669  0 M>  * Distribution context and assumption context.
EXAMINE VARIABLES=G3 BY studytime
1670  0 M>  EXAMINE VARIABLES=G3 BY studytime
  /PLOT BOXPLOT HISTOGRAM
1671  0 M>    /PLOT BOXPLOT HISTOGRAM
  /COMPARE GROUPS
1672  0 M>    /COMPARE GROUPS
```

```
  /STATISTICS DESCRIPTIVES
1673  0 M>    /STATISTICS DESCRIPTIVES
  /CINTERVAL 95
1674  0 M>    /CINTERVAL 95
  /MISSING LISTWISE
1675  0 M>    /MISSING LISTWISE
  /NOTOTAL.
1676  0 M>    /NOTOTAL.
```

## Explore

### Notes

| | | |
|---|---|---|
| Output Created | | 24-JUN-2026 14:49:31 |
| Comments | | |
| Input | Data | D:\DATA ANALYSIS\F Post Hoc Tests\Tukey HSD Test\dataset.csv |
| | Active Dataset | TukeyHSDData |
| | Filter | <none> |
| | Weight | <none> |
| | Split File | <none> |
| | N of Rows in Working Data File | 649 |
| Missing Value Handling | Definition of Missing | User-defined missing values for dependent variables are treated as missing. |
| | Cases Used | Statistics are based on cases with no missing values for any dependent variable or factor used. |
| Syntax | | EXAMINE VARIABLES=G3 BY studytime /PLOT BOXPLOT HISTOGRAM /COMPARE GROUPS /STATISTICS DESCRIPTIVES /CINTERVAL 95 /MISSING LISTWISE... |

Tukey HSD Test / Tukey-Kramer Post Hoc Analysis
One-way ANOVA followed by Tukey HSD pairwise comparisons for

### Notes

| | | |
|---|---|---|
| Resources | Processor Time | 00:00:01.64 |
| | Elapsed Time | 00:00:01.72 |

## Study time group / Tukey HSD factor

### Case Processing Summary

| | | Cases | | | | | |
|---|---|---|---|---|---|---|---|
| | | Valid | | Missing | | Total | |
| | studytime | N | Percent | N | Percent | N | Percent |
| G3 | Studytime 1: <2 hours | 212 | 100.0% | 0 | 0.0% | 212 | 100.0% |
| | Studytime 2: 2 to 5 hours | 305 | 100.0% | 0 | 0.0% | 305 | 100.0% |
| | Studytime 3: 5 to 10 hours | 97 | 100.0% | 0 | 0.0% | 97 | 100.0% |
| | Studytime 4: >10 hours | 35 | 100.0% | 0 | 0.0% | 35 | 100.0% |

### Descriptives

| | studytime | | | Statistic | Std. Error |
|---|---|---|---|---|---|
| G3 | Studytime 1: <2 hours | Mean | | 10.8443 | .22106 |
| | | 95% Confidence Interval for Mean | Lower Bound | 10.4086 | |
| | | | Upper Bound | 11.2801 | |
| | | 5% Trimmed Mean | | 11.0419 | |
| | | Median | | 11.0000 | |
| | | Variance | | 10.360 | |
| | | Std. Deviation | | 3.21862 | |
| | | Minimum | | .00 | |
| | | Maximum | | 18.00 | |
| | | Range | | 18.00 | |
| | | Interquartile Range | | 3.00 | |
| | | Skewness | | -1.078 | .167 |
| | | Kurtosis | | 3.117 | .333 |
| | Studytime 2: 2 to 5 hours | Mean | | 12.0918 | .18570 |
| | | 95% Confidence Interval for Mean | Lower Bound | 11.7264 | |
| | | | Upper Bound | 12.4572 | |
| | | 5% Trimmed Mean | | 12.2505 | |

Tukey HSD Test / Tukey-Kramer Post Hoc Analysis
One-way ANOVA followed by Tukey HSD pairwise comparisons for

## Descriptives

| studytime | | | Statistic | Std. Error |
|---|---|---|---|---|
| | Median | | 12.0000 | |
| | Variance | | 10.518 | |
| | Std. Deviation | | 3.24313 | |
| | Minimum | | .00 | |
| | Maximum | | 19.00 | |
| | Range | | 19.00 | |
| | Interquartile Range | | 4.00 | |
| | Skewness | | -1.028 | .140 |
| | Kurtosis | | 3.044 | .278 |
| Studytime 3: 5 to 10 hours | Mean | | 13.2268 | .25405 |
| | 95% Confidence Interval for Mean | Lower Bound | 12.7225 | |
| | | Upper Bound | 13.7311 | |
| | 5% Trimmed Mean | | 13.2732 | |
| | Median | | 13.0000 | |
| | Variance | | 6.261 | |
| | Std. Deviation | | 2.50210 | |
| | Minimum | | 8.00 | |
| | Maximum | | 18.00 | |
| | Range | | 10.00 | |
| | Interquartile Range | | 3.50 | |
| | Skewness | | -.190 | .245 |
| | Kurtosis | | -.502 | .485 |
| Studytime 4: >10 hours | Mean | | 13.0571 | .51358 |
| | 95% Confidence Interval for Mean | Lower Bound | 12.0134 | |
| | | Upper Bound | 14.1009 | |
| | 5% Trimmed Mean | | 13.0714 | |
| | Median | | 13.0000 | |
| | Variance | | 9.232 | |
| | Std. Deviation | | 3.03841 | |
| | Minimum | | 6.00 | |
| | Maximum | | 19.00 | |
| | Range | | 13.00 | |

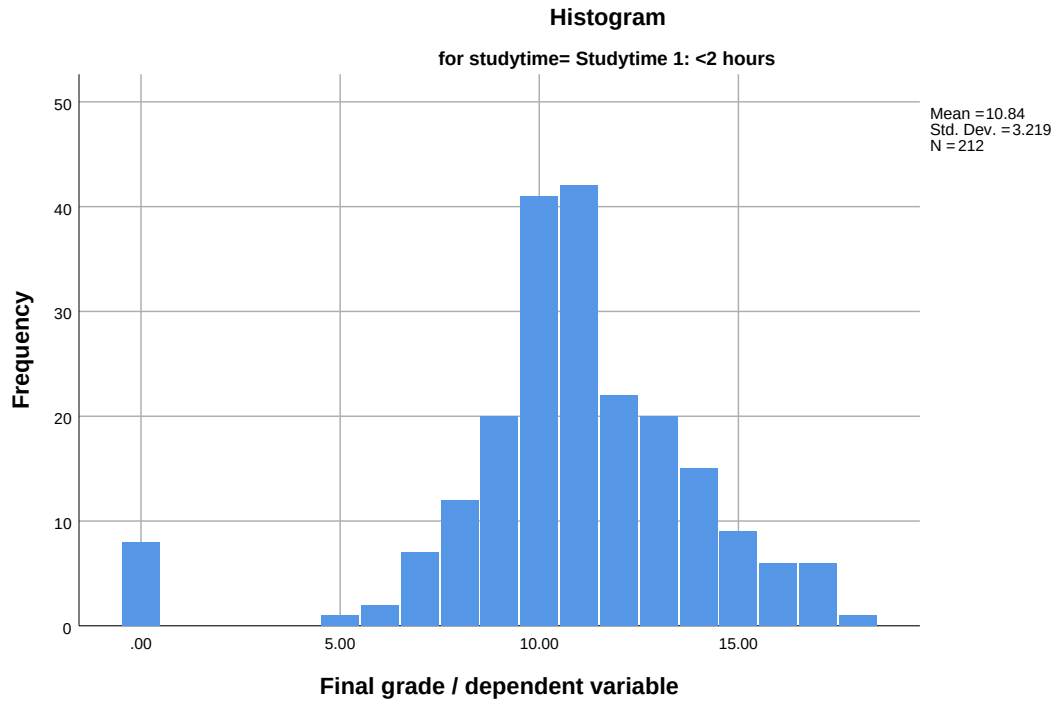
Tukey HSD Test / Tukey-Kramer Post Hoc Analysis
One-way ANOVA followed by Tukey HSD pairwise comparisons for

**Descriptives**

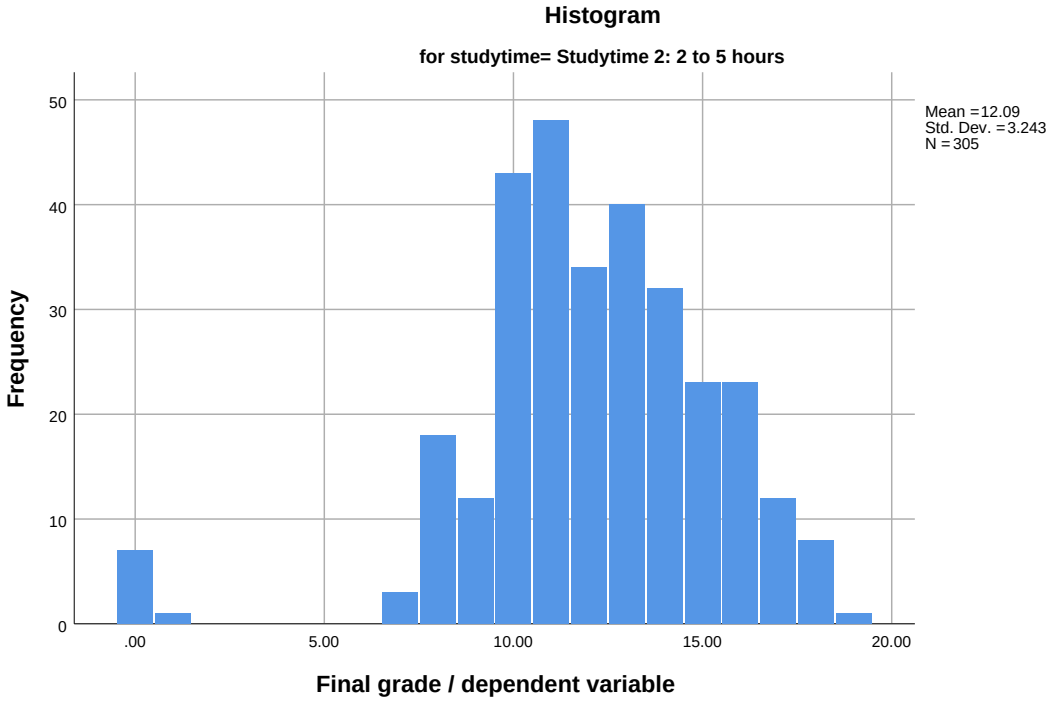
| studytime | | Statistic | Std. Error |
|---|---|---|---|
| | Interquartile Range | 4.00 | |
| | Skewness | .209 | .398 |
| | Kurtosis | -.339 | .778 |

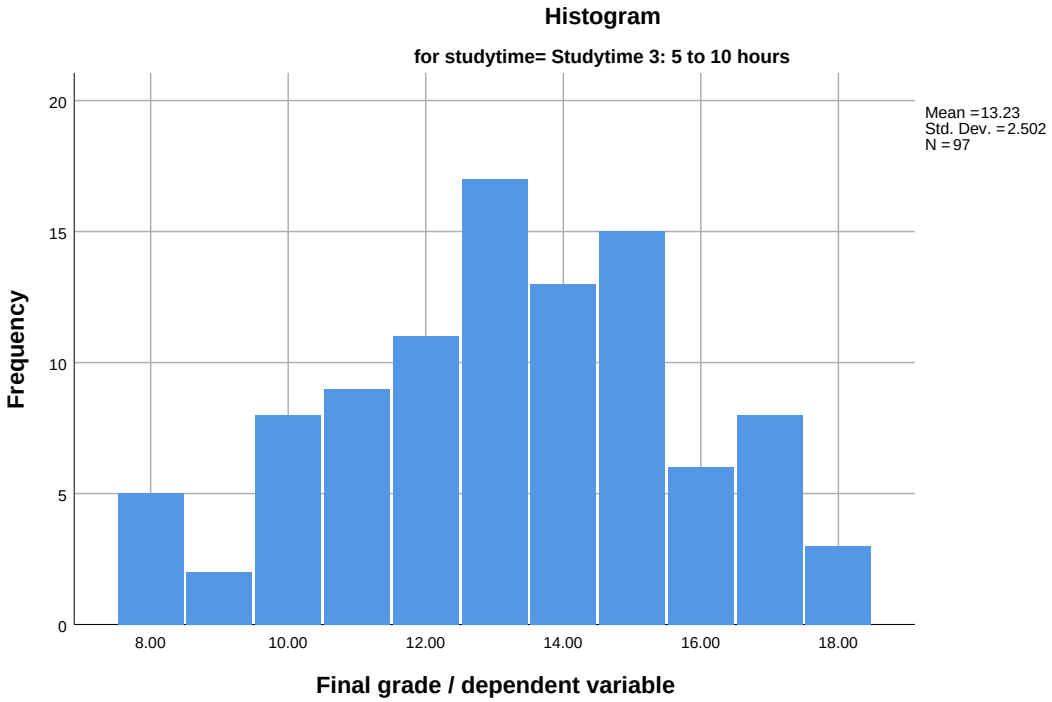
## Final grade / dependent variable

## Histograms

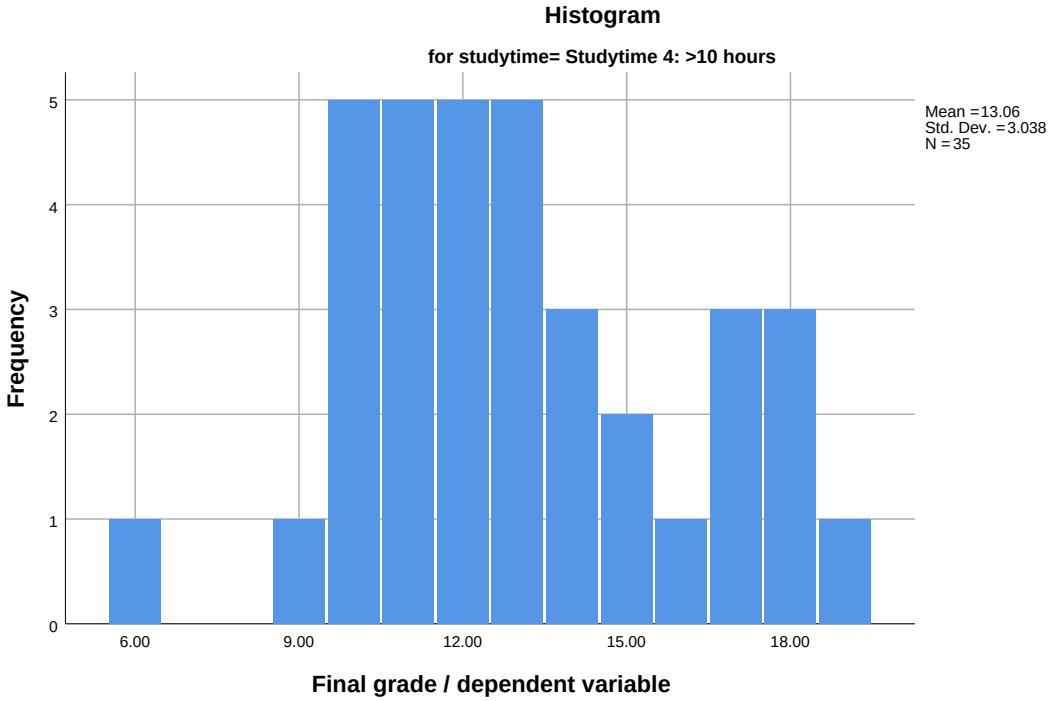


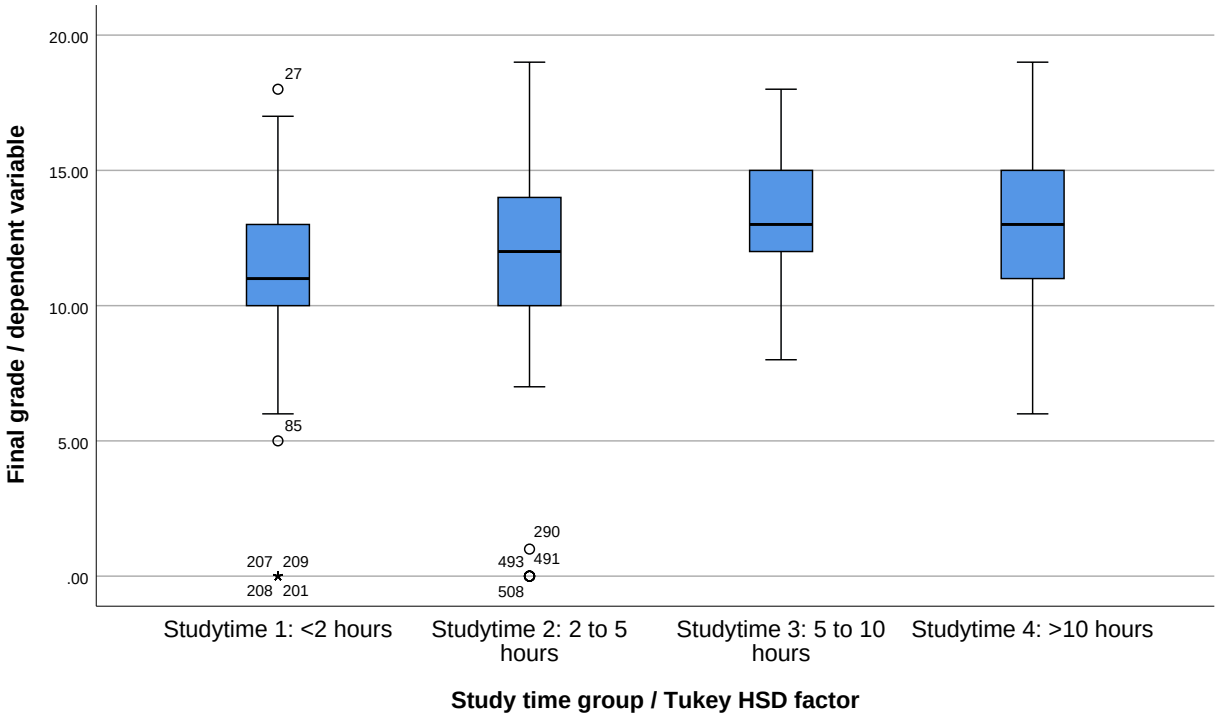
Tukey HSD Test / Tukey-Kramer Post Hoc Analysis
One-way ANOVA followed by Tukey HSD pairwise comparisons for



Tukey HSD Test / Tukey-Kramer Post Hoc Analysis
One-way ANOVA followed by Tukey HSD pairwise comparisons for




1677  0 M>

Tukey HSD Test / Tukey-Kramer Post Hoc Analysis
One-way ANOVA followed by Tukey HSD pairwise comparisons for

```
* Official SPSS one-way ANOVA with Tukey HSD post hoc test.
1678  0 M>  * Official SPSS one-way ANOVA with Tukey HSD post hoc test.
ONEWAY G3 BY studytime
1679  0 M>  ONEWAY G3 BY studytime
  /STATISTICS DESCRIPTIVES HOMOGENEITY WELCH BROWNFORSYTHE
1680  0 M>    /STATISTICS DESCRIPTIVES HOMOGENEITY WELCH BROWNFORSYTHE
  /PLOT MEANS
1681  0 M>    /PLOT MEANS
  /MISSING ANALYSIS
1682  0 M>    /MISSING ANALYSIS
  /POSTHOC=TUKEY ALPHA(0.05).
1683  0 M>    /POSTHOC=TUKEY ALPHA(0.05).
```

## Oneway

### Notes

| | | |
|---|---|---|
| Output Created | | 24-JUN-2026 14:49:33 |
| Comments | | |
| Input | Data | D:\DATA ANALYSIS\F Post Hoc Tests\Tukey HSD Test\dataset.csv |
| | Active Dataset | TukeyHSDData |
| | Filter | <none> |
| | Weight | <none> |
| | Split File | <none> |
| | N of Rows in Working Data File | 649 |
| Missing Value Handling | Definition of Missing | User-defined missing values are treated as missing. |
| | Cases Used | Statistics for each analysis are based on cases with no missing data for any variable in the analysis. |

Tukey HSD Test / Tukey-Kramer Post Hoc Analysis
One-way ANOVA followed by Tukey HSD pairwise comparisons for

## Notes

| | | |
|---|---|---|
| Syntax | | ONEWAY G3 BY studytime<br>/STATISTICS DESCRIPTIVES HOMOGENEITY WELCH BROWNFORSYTHE<br>/PLOT MEANS<br>/MISSING ANALYSIS<br>/POSTHOC=TUKEY ALPHA(0.05). |
| Resources | Processor Time | 00:00:00.39 |
| | Elapsed Time | 00:00:00.49 |

## Descriptives

G3

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence ... Lower Bound |
|---|---|---|---|---|---|
| Studytime 1: <2 hours | 212 | 10.8443 | 3.21862 | .22106 | 10.4086 |
| Studytime 2: 2 to 5 hours | 305 | 12.0918 | 3.24313 | .18570 | 11.7264 |
| Studytime 3: 5 to 10 hours | 97 | 13.2268 | 2.50210 | .25405 | 12.7225 |
| Studytime 4: >10 hours | 35 | 13.0571 | 3.03841 | .51358 | 12.0134 |
| Total | 649 | 11.9060 | 3.23066 | .12681 | 11.6570 |

## Descriptives

G3

| | 95% Confidence Interval for Mean Upper Bound | Minimum | Maximum |
|---|---|---|---|
| Studytime 1: <2 hours | 11.2801 | .00 | 18.00 |
| Studytime 2: 2 to 5 hours | 12.4572 | .00 | 19.00 |
| Studytime 3: 5 to 10 hours | 13.7311 | 8.00 | 18.00 |
| Studytime 4: >10 hours | 14.1009 | 6.00 | 19.00 |
| Total | 12.1550 | .00 | 19.00 |

Tukey HSD Test / Tukey-Kramer Post Hoc Analysis
One-way ANOVA followed by Tukey HSD pairwise comparisons for

### Test of Homogeneity of Variances

| | | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| G3 | Based on Mean | .985 | 3 | 645 | .400 |
| | Based on Median | 1.026 | 3 | 645 | .380 |
| | Based on Median and with adjusted df | 1.026 | 3 | 609.885 | .380 |
| | Based on trimmed mean | 1.081 | 3 | 645 | .356 |

### ANOVA

G3

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 465.078 | 3 | 155.026 | 15.876 | .000 |
| Within Groups | 6298.189 | 645 | 9.765 | | |
| Total | 6763.267 | 648 | | | |

### Robust Tests of Equality of Means

G3

| | Statistic[a] | df1 | df2 | Sig. |
|---|---|---|---|---|
| Welch | 18.183 | 3 | 139.101 | .000 |
| Brown-Forsythe | 17.478 | 3 | 246.552 | .000 |

a. Asymptotically F distributed.

## Post Hoc Tests

Tukey HSD Test / Tukey-Kramer Post Hoc Analysis
One-way ANOVA followed by Tukey HSD pairwise comparisons for

## Multiple Comparisons

Dependent Variable: G3

Tukey HSD

| (I) studytime | (J) studytime | Mean Difference (I-J) | Std. Error | Sig. |
|---|---|---|---|---|
| Studytime 1: <2 hours | Studytime 2: 2 to 5 hours | -1.24746* | .27942 | .000 |
| | Studytime 3: 5 to 10 hours | -2.38246* | .38305 | .000 |
| | Studytime 4: >10 hours | -2.21280* | .57013 | .001 |
| Studytime 2: 2 to 5 hours | Studytime 1: <2 hours | 1.24746* | .27942 | .000 |
| | Studytime 3: 5 to 10 hours | -1.13500* | .36425 | .010 |
| | Studytime 4: >10 hours | -.96534 | .55768 | .308 |
| Studytime 3: 5 to 10 hours | Studytime 1: <2 hours | 2.38246* | .38305 | .000 |
| | Studytime 2: 2 to 5 hours | 1.13500* | .36425 | .010 |
| | Studytime 4: >10 hours | .16966 | .61616 | .993 |
| Studytime 4: >10 hours | Studytime 1: <2 hours | 2.21280* | .57013 | .001 |
| | Studytime 2: 2 to 5 hours | .96534 | .55768 | .308 |
| | Studytime 3: 5 to 10 hours | -.16966 | .61616 | .993 |

Tukey HSD Test / Tukey-Kramer Post Hoc Analysis
One-way ANOVA followed by Tukey HSD pairwise comparisons for

### Multiple Comparisons

Dependent Variable: G3

Tukey HSD

| (I) studytime | (J) studytime | 95% Confidence Interval | |
|---|---|---|---|
| | | Lower Bound | Upper Bound |
| Studytime 1: <2 hours | Studytime 2: 2 to 5 hours | -1.9672 | -.5278 |
| | Studytime 3: 5 to 10 hours | -3.3691 | -1.3958 |
| | Studytime 4: >10 hours | -3.6813 | -.7443 |
| Studytime 2: 2 to 5 hours | Studytime 1: <2 hours | .5278 | 1.9672 |
| | Studytime 3: 5 to 10 hours | -2.0732 | -.1968 |
| | Studytime 4: >10 hours | -2.4018 | .4711 |
| Studytime 3: 5 to 10 hours | Studytime 1: <2 hours | 1.3958 | 3.3691 |
| | Studytime 2: 2 to 5 hours | .1968 | 2.0732 |
| | Studytime 4: >10 hours | -1.4174 | 1.7567 |
| Studytime 4: >10 hours | Studytime 1: <2 hours | .7443 | 3.6813 |
| | Studytime 2: 2 to 5 hours | -.4711 | 2.4018 |
| | Studytime 3: 5 to 10 hours | -1.7567 | 1.4174 |

*. The mean difference is significant at the 0.05 level.

## Homogeneous Subsets

Tukey HSD Test / Tukey-Kramer Post Hoc Analysis
One-way ANOVA followed by Tukey HSD pairwise comparisons for

**G3**

Tukey HSD[a,b]

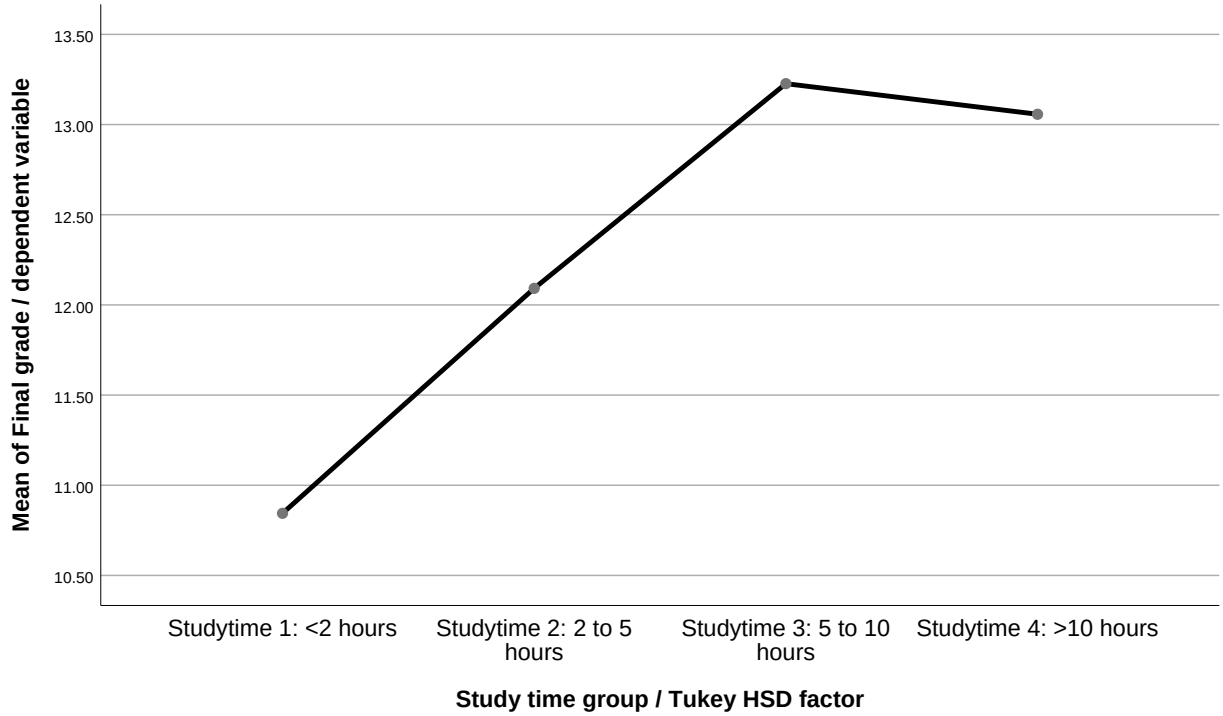
| studytime | N | Subset for alpha = 0.05 | |
|---|---|---|---|
| | | 1 | 2 |
| Studytime 1: <2 hours | 212 | 10.8443 | |
| Studytime 2: 2 to 5 hours | 305 | | 12.0918 |
| Studytime 4: >10 hours | 35 | | 13.0571 |
| Studytime 3: 5 to 10 hours | 97 | | 13.2268 |
| Sig. | | 1.000 | .083 |

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 85.331.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

## Means Plots




1684 0 M>

```
* GLM version for estimated means and profile chart.
1685  0 M>  * GLM version for estimated means and profile chart.
UNIANOVA G3 BY studytime
1686  0 M>  UNIANOVA G3 BY studytime
  /METHOD=SSTYPE(3)
1687  0 M>    /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
1688  0 M>    /INTERCEPT=INCLUDE
  /PLOT=PROFILE(studytime) TYPE=LINE ERRORBAR=CI MEANREFERENCE=NO YAXIS=AUTO
1689  0 M>    /PLOT=PROFILE(studytime) TYPE=LINE ERRORBAR=CI MEANREFERENCE=NO
YAXIS=AUTO
  /EMMEANS=TABLES(studytime) COMPARE ADJ(TUKEY)
1690  0 M>    /EMMEANS=TABLES(studytime) COMPARE ADJ(TUKEY)
  /PRINT=DESCRIPTIVE ETASQ HOMOGENEITY OPOWER
1691  0 M>    /PRINT=DESCRIPTIVE ETASQ HOMOGENEITY OPOWER
  /CRITERIA=ALPHA(.05)
1692  0 M>    /CRITERIA=ALPHA(.05)
  /DESIGN=studytime.
1693  0 M>    /DESIGN=studytime.
```

## Univariate Analysis of Variance

Tukey HSD Test / Tukey-Kramer Post Hoc Analysis
One-way ANOVA followed by Tukey HSD pairwise comparisons for

## Notes

| | | |
|---|---|---|
| Output Created | | 24-JUN-2026 14:49:34 |
| Comments | | |
| Input | Data | D:\DATA ANALYSIS\F Post Hoc Tests\Tukey HSD Test\dataset.csv |
| | Active Dataset | TukeyHSDData |
| | Filter | <none> |
| | Weight | <none> |
| | Split File | <none> |
| | N of Rows in Working Data File | 649 |
| Syntax | | UNIANOVA G3 BY studytime<br>/METHOD=SSTYPE(3)<br>/INTERCEPT=INCLUDE<br>/PLOT=PROFILE (studytime) TYPE=LINE ERRORBAR=CI MEANREFERENCE=NO YAXIS=AUTO<br>/EMMEANS=TABLES (studytime) COMPARE ADJ(TUKEY)<br>/PRINT=DESCRIPTIVE ETASQ HOMOGENEITY OPOWER<br>/CRITERIA=ALPHA(.05)<br>/DESIGN=studytime. |
| Resources | Processor Time | 00:00:00.02 |
| | Elapsed Time | 00:00:00.01 |

## Warnings

| |
|---|
| The symbol TUKEY was found in the ADJ specification in the EMMEANS subcommand where one of the keywords BONFERRONI, LSD, SIDAK was expected. |
| Execution of this command stops. |

```
1694  0 M>
* Optional SPSS-side PNG/CSV export. Any chart error is logged and does not st
op Viewer saving.
```

```
1695  0 M>  * Optional SPSS-side PNG/CSV export. Any chart error is logged and
 does not stop Viewer saving.
BEGIN PROGRAM Python3.
1696  0 M>  BEGIN PROGRAM Python3.
import os, math, itertools, traceback
base = r'D:\DATA ANALYSIS\F Post Hoc Tests\Tukey HSD Test'
out = os.path.join(base, 'SPSS_Output')
chart_dir = os.path.join(out, 'charts')
table_dir = os.path.join(out, 'tables')
pdf_dir = os.path.join(out, 'pdf')
for folder in [out, chart_dir, table_dir, pdf_dir]:
    os.makedirs(folder, exist_ok=True)
log_path = os.path.join(out, 'spss_python_chart_export_status.txt')
try:
    import numpy as np
    import pandas as pd
    import matplotlib.pyplot as plt
    dataset_path = os.path.join(base, 'dataset.csv')
    df = pd.read_csv(dataset_path)
    target = 'G3' if 'G3' in df.columns else df.select_dtypes(include=[np.numb
er]).columns[0]
    group_var = 'studytime' if 'studytime' in df.columns else None
    if group_var is None:
        for col in df.columns:
            if col != target and 3 <= df[col].dropna().nunique() <= 8:
                group_var = col
                break
    if group_var is None:
        raise ValueError('No valid 3-8 level grouping variable found for Tukey
 HSD chart export.')
    data = df[[target, group_var]].dropna().copy()
    data[target] = pd.to_numeric(data[target], errors='coerce')
    data = data.dropna()
    summary = data.groupby(group_var)[target].agg(['count', 'mean', 'std', 'va
r', 'min', 'max']).reset_index()
    summary.columns = ['group', 'n', 'mean', 'sd', 'variance', 'minimum', 'max
imum']
    summary['se'] = summary['sd'] / np.sqrt(summary['n'])
    summary['ci95_low'] = summary['mean'] - 1.96 * summary['se']
```

```
    summary['ci95_high'] = summary['mean'] + 1.96 * summary['se']
    summary.to_csv(os.path.join(table_dir, 'spss_tukey_group_summary.csv'), in
dex=False)
    ordered = summary.sort_values('mean').reset_index(drop=True)
    grand = data[target].mean()
    ss_within = 0.0
    for _, part in data.groupby(group_var):
        vals = part[target].to_numpy(float)
        ss_within += float(((vals - vals.mean()) ** 2).sum())
    k = len(summary)
    n_total = int(summary['n'].sum())
    df_within = n_total - k
    mse = ss_within / df_within
    try:
        from scipy.stats import studentized_range
        qcrit = float(studentized_range.ppf(0.95, k, df_within))
        get_p = lambda q: float(studentized_range.sf(q, k, df_within))
    except Exception:
        qcrit = 3.633 if k <= 4 else 4.030
        get_p = lambda q: float('nan')
    rows = []
    for i, j in itertools.combinations(range(k), 2):
        g1, g2 = ordered.loc[i], ordered.loc[j]
        diff = float(g2['mean'] - g1['mean'])
        se = math.sqrt((mse / 2) * ((1 / float(g1['n'])) + (1 / float(g2['n'])
)))
        q = abs(diff) / se if se > 0 else float('nan')
        threshold = qcrit * se
        rows.append({
            'group_1_lower_mean': str(g1['group']),
            'group_2_higher_mean': str(g2['group']),
            'mean_difference_2_minus_1': diff,
            'standard_error_tukey_kramer': se,
            'q_statistic': q,
            'q_critical_tukey': qcrit,
            'hsd_threshold': threshold,
            'simultaneous_ci_low': diff - threshold,
            'simultaneous_ci_high': diff + threshold,
            'adjusted_p_value_tukey_hsd': get_p(q),
```

```
            'decision_alpha_0_05': 'Significant' if q > qcrit else 'Not signif
icant'
        })
    pairwise = pd.DataFrame(rows)
    pairwise.to_csv(os.path.join(table_dir, 'spss_tukey_hsd_pairwise_chart_tab
le.csv'), index=False)
    palette = ['#2563EB','#DC2626','#16A34A','#9333EA','#F97316','#0891B2','#D
B2777','#65A30D']
    fig, ax = plt.subplots(figsize=(12,7))
    plot_data = summary.sort_values('mean', ascending=False)
    colors = [palette[i % len(palette)] for i in range(len(plot_data))]
    ax.bar(plot_data['group'].astype(str), plot_data['mean'], color=colors, ed
gecolor='#111827')
    ax.errorbar(plot_data['group'].astype(str), plot_data['mean'],
                yerr=[plot_data['mean']-plot_data['ci95_low'], plot_data['ci95
_high']-plot_data['mean']],
                fmt='none', ecolor='#111827', capsize=6)
    ax.set_title('SPSS Tukey HSD Group Means Context', fontsize=18, fontweight
='bold')
    ax.set_xlabel(group_var)
    ax.set_ylabel('Mean ' + target)
    fig.tight_layout()
    fig.savefig(os.path.join(chart_dir, 'spss_chart_01_tukey_group_means_conte
xt.png'), dpi=180)
    plt.close(fig)
    if not pairwise.empty:
        fig, ax = plt.subplots(figsize=(12, max(7, len(pairwise)*0.45)))
        plot_data = pairwise.sort_values('mean_difference_2_minus_1')
        y = np.arange(len(plot_data))
        labels = plot_data['group_1_lower_mean'] + ' vs ' + plot_data['group_2
_higher_mean']
        colors = ['#16A34A' if x == 'Significant' else '#F97316' for x in plot
_data['decision_alpha_0_05']]
        ax.hlines(y, plot_data['simultaneous_ci_low'], plot_data['simultaneous
_ci_high'], color='#111827')
        ax.scatter(plot_data['mean_difference_2_minus_1'], y, s=85, color=colo
rs, edgecolor='#111827')
        ax.axvline(0, color='#DC2626', linestyle='--', linewidth=2)
        ax.set_yticks(y)
```

```
        ax.set_yticklabels(labels)
        ax.set_xlabel('Mean difference with Tukey simultaneous CI')
        ax.set_title('SPSS Tukey HSD Simultaneous CI Chart', fontsize=18, font
weight='bold')
        fig.tight_layout()
        fig.savefig(os.path.join(chart_dir, 'spss_chart_02_tukey_simultaneous_
ci.png'), dpi=180)
        plt.close(fig)
        fig, ax = plt.subplots(figsize=(12,7))
        plot_data = pairwise.sort_values('q_statistic', ascending=False)
        labels = plot_data['group_1_lower_mean'] + ' vs ' + plot_data['group_2
_higher_mean']
        colors = ['#16A34A' if x == 'Significant' else '#F97316' for x in plot
_data['decision_alpha_0_05']]
        ax.bar(np.arange(len(plot_data)), plot_data['q_statistic'], color=colo
rs, edgecolor='#111827')
        ax.axhline(qcrit, color='#DC2626', linestyle='--', linewidth=2)
        ax.set_xticks(np.arange(len(plot_data)))
        ax.set_xticklabels(labels, rotation=35, ha='right')
        ax.set_ylabel('q statistic')
        ax.set_title('SPSS Tukey q Statistic vs Critical q', fontsize=18, font
weight='bold')
        fig.tight_layout()
        fig.savefig(os.path.join(chart_dir, 'spss_chart_03_tukey_q_statistic_v
s_critical.png'), dpi=180)
        plt.close(fig)
    with open(log_path, 'w', encoding='utf-8') as f:
        f.write('SPSS Python chart export completed successfully.\n')
except Exception:
    with open(log_path, 'w', encoding='utf-8') as f:
        f.write('SPSS Python chart export failed, but SPSS Viewer output will
still be saved/exported.\n\n')
        f.write(traceback.format_exc())
END PROGRAM.

1818  0 M>
* Automatic save/export block. This must remain at the very end of the syntax
file.
```

```
1819  0 M>  * Automatic save/export block. This must remain at the very end of
 the syntax file.
OUTPUT ACTIVATE TukeyHSDOutput.
1820  0 M>  OUTPUT ACTIVATE TukeyHSDOutput.
OUTPUT SAVE OUTFILE='D:\DATA ANALYSIS\F Post Hoc Tests\Tukey HSD Test\SPSS_Out
put\Tukey-HSD-Test-SPSS-Output.spv'.
1821  0 M>  OUTPUT SAVE OUTFILE='D:\DATA ANALYSIS\F Post Hoc Tests\Tukey HSD T
est\SPSS_Output\Tukey-HSD-Test-SPSS-Output.spv'.
```

## Output Save

### Notes

| | | |
|---|---|---|
| Output Created | | 24-JUN-2026 14:49:34 |
| Comments | | |
| Input | Data | D:\DATA ANALYSIS\F Post Hoc Tests\Tukey HSD Test\dataset.csv |
| | Active Dataset | TukeyHSDData |
| | Filter | <none> |
| | Weight | <none> |
| | Split File | <none> |
| Syntax | | OUTPUT SAVE OUTFILE='D:\DATA ANALYSIS\F Post Hoc Tests\Tukey HSD Test\SPSS_Output\Tukey-HSD-Test-SPSS-Output.spv'. |
| Resources | Processor Time | 00:00:00.02 |
| | Elapsed Time | 00:00:00.06 |

### Warnings

| |
|---|
| Cannot write to OUTFILE='D:\DATA ANALYSIS\F Post Hoc Tests\Tukey HSD Test\SPSS_Output\Tukey-HSD-Test-SPSS-Output.spv'. File is open in another window. |
| Execution of this command stops. |

```
OUTPUT EXPORT
1822  0 M>  OUTPUT EXPORT
```

```
  /CONTENTS EXPORT=ALL LAYERS=PRINTSETTING MODELVIEWS=PRINTSETTING
1823  0 M>    /CONTENTS EXPORT=ALL LAYERS=PRINTSETTING MODELVIEWS=PRINTSETTING
  /PDF DOCUMENTFILE='D:\DATA ANALYSIS\F Post Hoc Tests\Tukey HSD Test\SPSS_Out
put\pdf\Tukey-HSD-Test-SPSS-Output.pdf'
1824  0 M>    /PDF DOCUMENTFILE='D:\DATA ANALYSIS\F Post Hoc Tests\Tukey HSD T
est\SPSS_Output\pdf\Tukey-HSD-Test-SPSS-Output.pdf'
       EMBEDBOOKMARKS=YES
1825  0 M>         EMBEDBOOKMARKS=YES
```