

Cobb (2015 *Design and Analysis of Experiments* p 150) reported the age (in months) at which babies first walked. The goal of the study was to find if special (structured) exercise lowered the age, compared to 3 control groups: 12 minute/day of unstructured exercise, no exercise and a weekly parental report, no exercise and a single parental report at the end of the study. Six baby boys were assigned randomly to each level, only 5 values were obtained for single report babies.

| Age | Group |
|------|---------------|
| 9 | Special |
| 9.5 | Special |
| 9.75 | Special |
| 10 | Special |
| 13 | Special |
| 9.5 | Special |
| 11 | Exercise |
| 10 | Exercise |
| 10 | Exercise |
| 11.8 | Exercise |
| 10.5 | Exercise |
| 15 | Exercise |
| 11 | Weekly Report |
| 12 | Weekly Report |
| 9 | Weekly Report |
| 11.5 | Weekly Report |
| 13.3 | Weekly Report |
| 13 | Weekly Report |
| 13.3 | Single Report |
| 11.5 | Single Report |
| 12 | Single Report |
| 13.5 | Single Report |
| 11.5 | Single Report |

1. Write a GLM, using A for age, and Gr for Group. [5]

2. Complete the ANOVA table

3 groups compared, single report group not included

| | Df | Sum of Sq | Mean Sq | F Value | Pr(F) |
|-----------|----|-----------|---------|---------|-------|
| Group | 2 | 7.75 | 3.88 | 1.44 | 0.268 |
| Residuals | 15 | 40.41 | 2.69 | | |
| Total | 17 | 48.156 | | | |

[6]

3. Given the 'non-significant' decision, it is of interest to calculate the sample size needed to detect a difference among the three groups. To do this we recompute the ANOVA table with more degrees of freedom (df = more babies - 1). The formula is

new F-ratio = initial F-ratio * multiplier,
 where multiplier = $(df_{\text{additional}} + df_{\text{initial}}) / df_{\text{initial}}$
 df_{initial} = Residual df in the table above.

| additional df | multiplier | New F-ratio | p(F<0.05) |
|---------------|------------|-------------|-----------|
| 0 | 1 | | |
| 10 | 1.59 | 2.28 | 0.1227 |
| 15 | | | 0.0830 |
| 20 | | | 0.0561 |
| 25 | 2.47 | 3.55 | 0.0380 ← |
| 30 | 2.76 | 3.98 | 0.0257 |

3a. Fill in the two boxes in the table [2]

3b. Use the p-values to estimate the additional df needed in a future study. Circle your estimated additional df [1]

3c Calculate the multiplier and the F-ratio for your estimate. [2]

Calculations like this are required in clinical trials and with animal studies. In other research areas, calculations like this can prevent waste of time and effort on experimental programs that are 'doomed to failure' because of inadequate replication and high variability due to poor experimental controls.

This is the calculation based on df total instead of df residual

3 groups compared, weekly report group not included

| | Df | Sum of Sq | Mean Sq | F-ratio | Pr(F) |
|-----------|----|-----------|---------|---------|-------|
| Group | 2 | 13.72 | 6.86 | 2.99 | 0.083 |
| Residuals | 14 | 32.14 | 2.30 | | |
| Total | 16 | 45.86 | | | |

| | additional | additional | additional | New | New | New |
|--|------------|------------|------------|-----------|-----|-----|
| | df | multiplier | F-ratio | p(F<0.05) | | |
| | 0 | 1.000 | | | | |
| | 2 | 1.125 | 3.36 | 0.0604 | | |
| | 4 | 1.250 | 3.74 | 0.0439 | | |
| | 6 | 1.375 | 4.11 | 0.0320 | | |
| | 8 | 1.500 | 4.48 | 0.0233 | | |
| | 10 | 1.625 | 4.86 | 0.0169 | | |

3 groups compared, weekly report group not included

| | Df | Sum of Sq | Mean Sq | F-ratio | Pr(F) |
|-----------|----|-----------|---------|---------|-------|
| Group | | 13.72 | | | 0.083 |
| Residuals | | | | | |
| Total | 16 | 45.86 | | | |

3 groups compared, single report group not included

| | Df | Sum of Sq | Mean Sq | F Value | Pr(F) |
|-----------|----|-----------|---------|---------|-------|
| Group | 2 | 7.75 | 3.88 | 1.44 | 0.268 |
| Residuals | 15 | 40.41 | 2.69 | | |
| Total | 17 | 48.16 | | | |

| | additional | additional | additional | New | New | New |
|--|------------|------------|------------|-----------|-----|-----|
| | df | multiplier | F-ratio | p(F<0.05) | | |
| | 0 | 1.000 | | | | |
| | 10 | 1.588 | 2.28 | 0.1227 | | |
| | 15 | 1.882 | 2.71 | 0.0830 | | |
| | 20 | 2.176 | 3.13 | 0.0561 | | |
| | 25 | 2.471 | 3.55 | 0.0380 | | |
| | 30 | 2.765 | 3.98 | 0.0257 | | |

3 groups compared, single report group not included

| | Df | Sum of Sq | Mean Sq | F Value | Pr(F) |
|-----------|----|-----------|---------|---------|-------|
| Group | | 7.75 | | | 0.268 |
| Residuals | | | | | |
| Total | 17 | 48.156 | | | |