Lecture 24: Analysis of Block Designs

**Example**

*Response: torque on knee*
*Conditions: placement of feet*
*Feet back, feet neutral, feet staggered*
*Experimental Material: men who have had knee replacement.*

**Reusing**

*Reuse the experimental material so that each piece of experimental material experiences all the treatments in a random order.*

**Reusing Material**

*Each person will sit in a chair and rise to a standing position.*
*Each person will do this three times, once with each foot position.*
*The order of the three foot positions will be randomized for each person.*

**Control of Outside Variables**

*Older males.*
*All have had total knee arthroplasty (replacement).*
*Height of chair constant.*
*All participants wear tennis shoes and comfortable clothing.*

**Randomization**

*Each participant experiences all three conditions (placement of feet) in a random order.*

**Randomization**

*Use three colored chips;*
*Red – Feet Neutral*
*White – Feet Back*
*Blue – Feet Staggered*
*Each participant draws chips without replacement to determine his order of treatments.*
Lecture 24: Analysis of Block Designs

**Replication**

* There are 15 participants.
* The treatments (foot positions) are replicated 15 times.

**Sample Size Tables**

* Although constructed for completely randomized designs, the sample size tables can give us insight into the size of the detectable difference in treatment means.

**Sample Size Tables**

* 3 groups.
* Alpha = 0.05, Beta = 0.10
* n = 15 per group.
* Can detect between a 1.2 and 1.4 standard deviation difference in treatment sample means.

**Informal Analysis**

<table>
<thead>
<tr>
<th>Method</th>
<th>Neutral</th>
<th>Back</th>
<th>Staggered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>24.1 Nm</td>
<td>21.7 Nm</td>
<td>20.7 Nm</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>3.8582</td>
<td>2.9835</td>
<td>2.3719</td>
</tr>
</tbody>
</table>

**Estimated Effects**

* Neutral: 24.1 – 22.167 = 1.933
* Back: 21.7 – 22.167 = – 0.467
* Staggered: 20.7 – 22.167 = – 1.467
Estimated Effects

* Staggered reduces the torque the most, on average.
* Neutral increases the torque the most, on average.
* Are these effects statistically significant?

Analysis of Variance

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Prob &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>2</td>
<td>91.60</td>
<td>45.8</td>
<td>31.84</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Subject</td>
<td>14</td>
<td>371.51</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>28</td>
<td>40.27</td>
<td>1.4383</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Total</td>
<td>44</td>
<td>503.38</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Test of Hypothesis

* H₀: all method effects are 0
* Hₐ: some method effects are not 0
* F = 31.84, P-value < 0.0001

Multiple Comparisons

LSD = t*√MS_{Error} \left(\frac{1}{n_1} + \frac{1}{n_2}\right)

LSD = 2.04841\sqrt{1.4383} \frac{2}{\sqrt{15}}

= 2.04841(0.43792) = 0.897

Levels not connected by the same letter are significantly different.
Lecture 24: Analysis of Block Designs

Conclusion

* Each method produces a different mean torque which is statistically different from the other methods.

JMP

* Analyze – Fit Model
* Response – Torque
* Construct Model Effects
  * Method
  * Subject

Response Torque

<table>
<thead>
<tr>
<th>Summary of Fit</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSquare</td>
</tr>
<tr>
<td>RSquare Adj</td>
</tr>
<tr>
<td>Root Mean Square Error</td>
</tr>
<tr>
<td>Mean of Response</td>
</tr>
<tr>
<td>Observations (or Sum Wgts)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analysis of Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
</tr>
<tr>
<td>Model</td>
</tr>
<tr>
<td>Error</td>
</tr>
<tr>
<td>C. Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effect Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
</tr>
<tr>
<td>Method</td>
</tr>
<tr>
<td>Subject</td>
</tr>
</tbody>
</table>

Comment

* The summary RSquare and Model F-Ratio are not helpful in summarizing the effects of Methods on Torque.

Comment

* Method RSquare $\frac{91.6}{503.38} = 0.182$
* 18.2% of the variation in Torque is explained by the different Methods.

Comment

* The Subject term quantifies the variation in experimental material.
* The Error term quantifies the lack of consistency of Method effects across Subjects.
Lecture 24: Analysis of Block Designs

Analysis of Variance

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>2</td>
<td>91.60</td>
</tr>
<tr>
<td>Subject</td>
<td>14</td>
<td>371.51</td>
</tr>
<tr>
<td>Interaction</td>
<td>28</td>
<td>40.27</td>
</tr>
<tr>
<td>Error</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C. Total</td>
<td>44</td>
<td>503.38</td>
</tr>
</tbody>
</table>

Replication

*Although there is replication of the Methods (15 subjects do all three Methods) there is not replication of the Method by Subject combinations.

“Error”

*There is no way to estimate error due to different trials of Method for each Subject because each Subject uses each Method only once.

“Error”

*The Error term is actually the interaction between Method and Subject.
*In a Block design this interaction is assumed to be no different from random error.

Interpretation

*If the F test for treatment effects turns out to be not statistically significant, this could be due to no treatment effects or to no consistent treatment effects.

Interpretation

*If some treatments are better with some blocks and worse for others, the “Error” term will be large and so there may be no statistically significant consistent treatment effects.