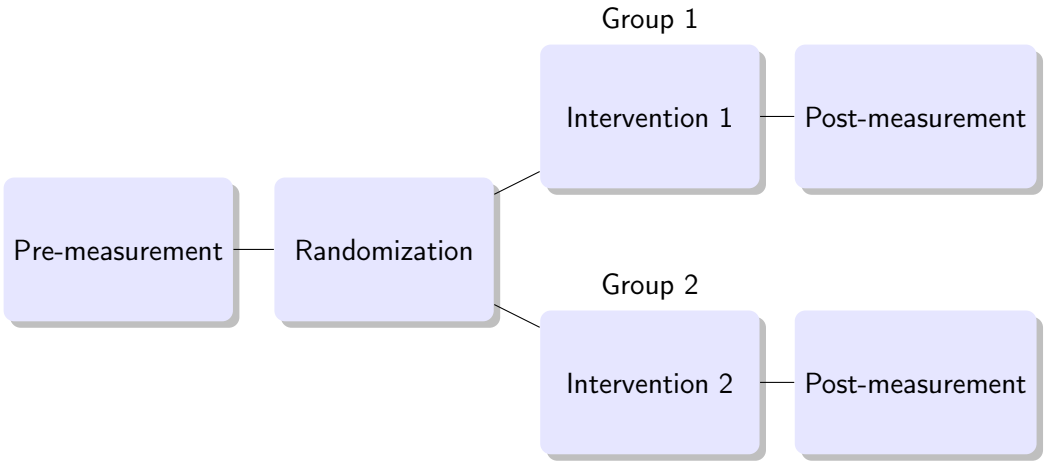
ANCOVA for Baseline/Follow-Up Measurements

Examples and Power Simulation

Last modified: 2026-03-09

Randomized controlled trial



Example: Acupuncture and shoulder pain

- Kleinhenz et al. (1999) studied the effectiveness of acupuncture in improving mobility in 52 patients with shoulder pain
- Patients were randomly assigned to two groups (placebo and acupuncture)
- A mobility score (Constant Murley Score) was assessed before and at the end of the treatment
- Vickers and Altman (2001) use these data to illustrate the advantages of analysis of covariance over other methods

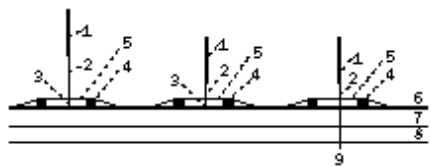
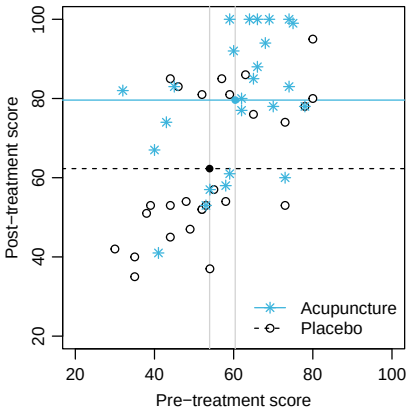


Figure 1: **Placebo needle**

Example: Acupuncture and shoulder pain

Follow-up analysis



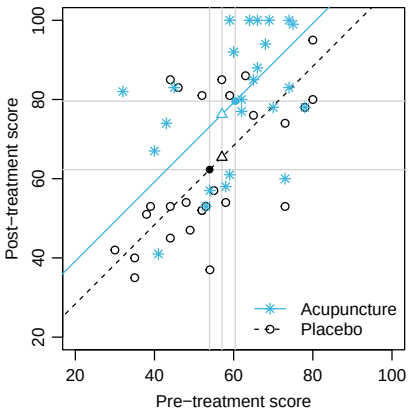
	Pla	Acu	Diff
Baseline	53.9	60.4	6.5
Follow up	62.3	79.6	17.3
Change sc.	8.4	19.2	10.8
ANCOVA			12.7

$$y_{i2} = \beta_0 + \beta_1 x_i + \varepsilon_i$$

$$\hat{\beta}_1 = 17.3, 0.95 \text{ CI: } (7.5, 27.1)$$

Example: Acupuncture and shoulder pain

Change-score analysis



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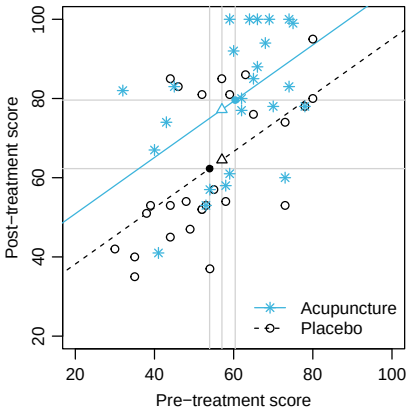
$$y_{i2} = \beta_0 + y_{i1} + \beta_1 x_i + \varepsilon_i$$

$$\hat{\beta}_1 = 10.8\ (2.3, 19.4)$$

Example: Acupuncture and shoulder pain

ANCOVA



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$$y_{i2} = \beta_0 + \beta_1\, y_{i1} + \beta_2\, x_i + \varepsilon_i$$

$$\hat{\beta}_2 = 12.7\ (4.1, 21.3)$$

Statistical modeling 1

- Follow-up analysis

```
m1 <- lm(post ~ grp, dat)
#             Estimate Std. Error t value Pr(>|t|)
# (Intercept)    62.30       3.38   18.44  < 2e-16
# grpacu         17.30       4.87    3.55  0.00085
```

- Change-score analysis

```
m2 <- lm(post ~ offset(pre) + grp, dat)
#             Estimate Std. Error t value Pr(>|t|)
# (Intercept)     8.37       2.95    2.84   0.0065
# grpacu         10.83       4.25    2.55   0.0140
```

Statistical modeling 2

- ANCOVA

```
m3 <- lm(post ~ pre + grp, dat)
#             Estimate Std. Error t value Pr(>|t|)
# (Intercept)    24.00       9.11    2.63   0.0113
# pre             0.71       0.16    4.43  5.2e-05
# grpacu         12.71       4.29    2.96   0.0047
```

- Baseline-adjusted means

```
predict(m3,
        data.frame(pre = mean(dat$pre),
                   grp = c("plac", "acu"))
)
#    1    2
# 64.5 77.2
```

References

Kleinhenz, J., Streitberger, K., Windeler, J., Güßbacher, A., Mavridis, G., & Martin, E. (1999). Randomised clinical trial comparing the effects of acupuncture and a newly designed placebo needle in rotator cuff tendinitis. *Pain*, *83*(2), 235–241.

Vickers, A. J., & Altman, D. G. (2001). Analysing controlled trials with baseline and follow up measurements. *BMJ*, *323*(7321), 1123–1124. doi: 10.1136/bmj.323.7321.1123