# Two-Sided Group Sequential Tests

## Pocock

Table 2.1 *Pocock tests: constants $C_P(K, \alpha)$ for two-sided tests with K groups of observations and Type I error probability $\alpha$*

| | $C_P(K, \alpha)$ | | |
|---|---|---|---|
| $K$ | $\alpha = 0.01$ | $\alpha = 0.05$ | $\alpha = 0.10$ |
| 1 | 2.576 | 1.960 | 1.645 |
| 2 | 2.772 | 2.178 | 1.875 |
| 3 | 2.873 | 2.289 | 1.992 |
| 4 | 2.939 | 2.361 | 2.067 |
| 5 | 2.986 | 2.413 | 2.122 |
| 6 | 3.023 | 2.453 | 2.164 |
| 7 | 3.053 | 2.485 | 2.197 |
| 8 | 3.078 | 2.512 | 2.225 |
| 9 | 3.099 | 2.535 | 2.249 |
| 10 | 3.117 | 2.555 | 2.270 |
| 11 | 3.133 | 2.572 | 2.288 |
| 12 | 3.147 | 2.588 | 2.304 |
| 15 | 3.182 | 2.626 | 2.344 |
| 20 | 3.225 | 2.672 | 2.392 |

Table 2.2 *Pocock tests: constants $R_P(K, \alpha, \beta)$ to determine group sizes for two-sided tests with K groups of observations, Type I error probability $\alpha$ and power $1 - \beta$*

| | $R_P(K, \alpha, \beta)$ | | | | | |
|---|---|---|---|---|---|---|
| | $1 - \beta = 0.8$ | | | $1 - \beta = 0.9$ | | |
| $K$ | $\alpha$=0.01 | $\alpha$=0.05 | $\alpha$=0.10 | $\alpha$=0.01 | $\alpha$=0.05 | $\alpha$=0.10 |
| 1 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 2 | 1.092 | 1.110 | 1.121 | 1.084 | 1.100 | 1.110 |
| 3 | 1.137 | 1.166 | 1.184 | 1.125 | 1.151 | 1.166 |
| 4 | 1.166 | 1.202 | 1.224 | 1.152 | 1.183 | 1.202 |
| 5 | 1.187 | 1.229 | 1.254 | 1.170 | 1.207 | 1.228 |
| 6 | 1.203 | 1.249 | 1.277 | 1.185 | 1.225 | 1.249 |
| 7 | 1.216 | 1.265 | 1.296 | 1.197 | 1.239 | 1.266 |
| 8 | 1.226 | 1.279 | 1.311 | 1.206 | 1.252 | 1.280 |
| 9 | 1.236 | 1.291 | 1.325 | 1.215 | 1.262 | 1.292 |
| 10 | 1.243 | 1.301 | 1.337 | 1.222 | 1.271 | 1.302 |
| 11 | 1.250 | 1.310 | 1.348 | 1.228 | 1.279 | 1.312 |
| 12 | 1.257 | 1.318 | 1.357 | 1.234 | 1.287 | 1.320 |
| 15 | 1.272 | 1.338 | 1.381 | 1.248 | 1.305 | 1.341 |
| 20 | 1.291 | 1.363 | 1.411 | 1.264 | 1.327 | 1.367 |

## O'Brien - Fleming

Table 2.3 *O'Brien & Fleming tests: constants $C_B(K, \alpha)$ for two-sided tests with K groups of observations and Type I error probability $\alpha$*

| | $C_B(K, \alpha)$ | | |
|---|---|---|---|
| $K$ | $\alpha = 0.01$ | $\alpha = 0.05$ | $\alpha = 0.10$ |
| 1 | 2.576 | 1.960 | 1.645 |
| 2 | 2.580 | 1.977 | 1.678 |
| 3 | 2.595 | 2.004 | 1.710 |
| 4 | 2.609 | 2.024 | 1.733 |
| 5 | 2.621 | 2.040 | 1.751 |
| 6 | 2.631 | 2.053 | 1.765 |
| 7 | 2.640 | 2.063 | 1.776 |
| 8 | 2.648 | 2.072 | 1.786 |
| 9 | 2.654 | 2.080 | 1.794 |
| 10 | 2.660 | 2.087 | 1.801 |
| 11 | 2.665 | 2.092 | 1.807 |
| 12 | 2.670 | 2.098 | 1.813 |
| 15 | 2.681 | 2.110 | 1.826 |
| 20 | 2.695 | 2.126 | 1.842 |

Table 2.4 *O'Brien & Fleming tests: constants $R_B(K, \alpha, \beta)$ to determine group sizes of two-sided tests with K groups of observations, Type I error probability $\alpha$ and power $1 - \beta$*

| | $R_B(K, \alpha, \beta)$ | | | | | |
|---|---|---|---|---|---|---|
| | $1 - \beta = 0.8$ | | | $1 - \beta = 0.9$ | | |
| $K$ | $\alpha$=0.01 | $\alpha$=0.05 | $\alpha$=0.10 | $\alpha$=0.01 | $\alpha$=0.05 | $\alpha$=0.10 |
| 1 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 2 | 1.001 | 1.008 | 1.016 | 1.001 | 1.007 | 1.014 |
| 3 | 1.007 | 1.017 | 1.027 | 1.006 | 1.016 | 1.025 |
| 4 | 1.011 | 1.024 | 1.035 | 1.010 | 1.022 | 1.032 |
| 5 | 1.015 | 1.028 | 1.040 | 1.014 | 1.026 | 1.037 |
| 6 | 1.017 | 1.032 | 1.044 | 1.016 | 1.030 | 1.041 |
| 7 | 1.019 | 1.035 | 1.047 | 1.018 | 1.032 | 1.044 |
| 8 | 1.021 | 1.037 | 1.049 | 1.020 | 1.034 | 1.046 |
| 9 | 1.022 | 1.038 | 1.051 | 1.021 | 1.036 | 1.048 |
| 10 | 1.024 | 1.040 | 1.053 | 1.022 | 1.037 | 1.049 |
| 11 | 1.025 | 1.041 | 1.054 | 1.023 | 1.039 | 1.051 |
| 12 | 1.026 | 1.042 | 1.055 | 1.024 | 1.040 | 1.052 |
| 15 | 1.028 | 1.045 | 1.058 | 1.026 | 1.042 | 1.054 |
| 20 | 1.030 | 1.047 | 1.061 | 1.029 | 1.045 | 1.057 |

## Wang-Tsiatis

Table 2.9 *Wang & Tsiatis tests: constants $C_{WT}(K, \alpha, \Delta)$ for two-sided tests with K groups of observations and Type I error probability $\alpha = 0.05$*

| | $C_{WT}(K, \alpha, \Delta)$ | | |
|---|---|---|---|
| | $\alpha = 0.05$ | | |
| $K$ | $\Delta = 0.1$ | $\Delta = 0.25$ | $\Delta = 0.4$ |
| 1 | 1.960 | 1.960 | 1.960 |
| 2 | 1.994 | 2.038 | 2.111 |
| 3 | 2.026 | 2.083 | 2.186 |
| 4 | 2.050 | 2.113 | 2.233 |
| 5 | 2.068 | 2.136 | 2.267 |
| 6 | 2.083 | 2.154 | 2.292 |
| 7 | 2.094 | 2.168 | 2.313 |
| 8 | 2.104 | 2.180 | 2.329 |
| 9 | 2.113 | 2.190 | 2.343 |
| 10 | 2.120 | 2.199 | 2.355 |
| 11 | 2.126 | 2.206 | 2.366 |
| 12 | 2.132 | 2.213 | 2.375 |
| 15 | 2.146 | 2.229 | 2.397 |
| 20 | 2.162 | 2.248 | 2.423 |

Table 2.10 *Wang & Tsiatis tests: constants $R_{WT}(K, \alpha, \beta, \Delta)$ to determine group sizes for two-sided tests with K groups of observations, Type I error probability $\alpha = 0.05$ and power $1 - \beta$*

| | $R_{WT}(K, \alpha, \beta, \Delta)$ | | | | | |
|---|---|---|---|---|---|---|
| | $\alpha = 0.05$ | | | | | |
| | $1 - \beta = 0.8$ | | | $1 - \beta = 0.9$ | | |
| $K$ | $\Delta$=0.1 | $\Delta$=0.25 | $\Delta$=0.4 | $\Delta$=0.1 | $\Delta$=0.25 | $\Delta$=0.4 |
| 1 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 2 | 1.016 | 1.038 | 1.075 | 1.014 | 1.034 | 1.068 |
| 3 | 1.027 | 1.054 | 1.108 | 1.025 | 1.050 | 1.099 |
| 4 | 1.035 | 1.065 | 1.128 | 1.032 | 1.059 | 1.117 |
| 5 | 1.040 | 1.072 | 1.142 | 1.037 | 1.066 | 1.129 |
| 6 | 1.044 | 1.077 | 1.152 | 1.041 | 1.071 | 1.138 |
| 7 | 1.047 | 1.081 | 1.159 | 1.044 | 1.075 | 1.145 |
| 8 | 1.050 | 1.084 | 1.165 | 1.046 | 1.078 | 1.151 |
| 9 | 1.052 | 1.087 | 1.170 | 1.048 | 1.081 | 1.155 |
| 10 | 1.054 | 1.089 | 1.175 | 1.050 | 1.083 | 1.159 |
| 11 | 1.055 | 1.091 | 1.178 | 1.051 | 1.085 | 1.163 |
| 12 | 1.056 | 1.093 | 1.181 | 1.053 | 1.086 | 1.166 |
| 15 | 1.059 | 1.097 | 1.189 | 1.055 | 1.090 | 1.172 |
| 20 | 1.062 | 1.101 | 1.197 | 1.058 | 1.094 | 1.180 |