Reliability of $W'$ using time-trials under laboratory conditions

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Introduction
Critical power (CP) and the maximum work above CP ($W'$) serve as important parameters to characterize high intensity exercise (Jones et al. 2010). However, recent research reported poor reproducibility of $W'$ (Galbraith et al. 2011; Karsten et al. 2015; Triska et al. 2015) and it was suggested that differences in the environmental conditions (e.g. terrain, seating position) or exhaustive durations might have influenced $W'$ between tests.

Therefore, the aim of this study was to determine $W'$ under controlled laboratory conditions using time-trials (TT). We hypothesized non-significant differences and a high reliability for $W'$.

Methods
Ten well-trained cyclists (MAP: 329±41 W) participated in this study. Reliability was assessed across three tests comprising three exhaustive TT each. These TT were 12, 7, and 3 min in duration and interspersed by 30 min passive rest. Tests were separated by at least 72 h. TTs were performed on a Cyclus2 ergometer (RBM Elektronik GmbH, Leipzig, Germany) where the participants' personal bikes were mounted on. To replicate real-world TT cycling, participants consequently utilised a self-pacing strategy were gearing was adjusted throughout efforts using the virtual gear changer mounted to the handlebars. $W'$ was estimated using a linear regression where power is plotted against the inverse of time ($1.s^{-1}$):

$$P = W'.t^{-1} + CP$$

where $P$ is the power output (W) and $t$ is the time (s). The standard error (SE) for $W'$ was calculated in absolute and relative values for each test.

A repeated measures ANOVA assessed the differences between the trials and significant main effects were followed-up by Bonferroni post-hoc procedures. Reliability was analysed using the intra-class correlation coefficient (ICC) and the coefficient of variation (CoV) (Hopkins 2000). Statistical significance was set at $P<.050$.

Results
Table 1 illustrates the results of the tests. Non-significant differences between repeated tests were revealed for $W'$ ($F_{1.513.9.935} = 2.951; P = .115$). However, significant differences were found for the absolute and relative SE ($F_{2.18} = 10.865; P = .001$; and $F_{2.18} = 5.428; P = .014$, respectively). Using Bonferroni post-hoc procedures, absolute SE of Test I was significantly higher compared to Test II and Test III ($P = .008-.042$).

Discussion and Conclusions
Using TT efforts in trained cyclists, a learning effect for $W'$ between Test I-Test II was identified. Furthermore, the ICC was low between Test I-Test II, but high for Test II-Test III. This is supported by CoV values for Test I-Test II which were notably above the recommended upper limit of 10% (Atkinson and Nevill 1998), however, improved to acceptable values in the following tests. The relative SE of the first test was slightly above the accepted upper limit of 10% (Ferguson et al. 2013), but well below that in the two following tests. Furthermore, absolute SE was significantly lower in Test II and Test III. To accurately determine $W'$ our findings suggest a familiarisation trial even when testing trained cyclists.
Table 1: Results of the three tests to determine $W'$

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<tr>
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<th>Test I</th>
<th>Test II</th>
<th>Test III</th>
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<tbody>
<tr>
<td>$W'$ (J)</td>
<td>17316 ± 6340</td>
<td>14972 ± 3052</td>
<td>14710 ± 3368</td>
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<tr>
<td>SE (J)</td>
<td>2012 ± 963</td>
<td>1060 ± 896*</td>
<td>868 ± 825*</td>
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<tr>
<td>SE (%)</td>
<td>12.6 ± 7.4</td>
<td>7.3 ± 6.5</td>
<td>6.0 ± 6.0</td>
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<tr>
<td>ICC (95%CL) Test I-Test II</td>
<td>0.58 (-0.03 to 0.88)</td>
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<tr>
<td>ICC (95%CL) Test II-Test III</td>
<td>0.95 (0.80 to 0.99)</td>
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<tr>
<td>CoV (%) (95%CL) Test I-Test II</td>
<td>25.3 (16.8 to 50.9)</td>
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<tr>
<td>CoV (%) (95%CL) Test II-Test III</td>
<td>8.2 (5.6 to 15.5)</td>
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$W'$ = maximum work above CP; SE = standard error of the estimate; ICC = intra-class correlation coefficient; CL = confidence limits; CoV = coefficient of variation; *significantly different from Test I at $P<.050$. and FTP$_{60}$ values (Panel A) and the correlation between CP and FTP$_{60}$ values (Panel B).

References

Key words: time-trials, Cyclus2, power-duration relationship, familiarisation