VARIABILITY IN COMPETITIVE PERFORMANCE OF ELITE TRACK CYCLISTS

Nick Flyger

National Sports Institute of Malaysia, National Sports Complex, Kuala Lumpur, Malaysia

This study calculated the individual variation in performance times for cyclists competing in international track cycling events as Typical Error and attempted to express that variation in terms of power. Performance times were collated from six international events during the 2005/06 UCI Track Season and log transformed. Typical Error was calculated via the back transformation of the RMSE from a two-way ANOVA excluding the interaction term. The average Typical Error over all events was 1.0% (0.8 – 1.3 95% CL). Theoretically when performance is expressed as average power, the variation is approximately 3%. Modelling of power output for typical male and female pursuit cyclists appears to confirm this relationship under typical race conditions. These results can be used to assess the suitability of a field-based aerodynamic test for measuring the smallest worthwhile performance enhancing change in drag, whether a cyclist has shown worthwhile improvements in power during a laboratory performance test or in performance time during a competitive season.

KEY WORDS: Cycling, Variability, Performance.

INTRODUCTION: Good coaches will monitor performance over time searching for trends due to training effects, the environment, injury etc…, which influence their athlete's performance. To judge whether a certain coaching or sport science intervention has been successful it is important to know how variable an athlete's performances are and the smallest worthwhile change (beneficial or harmful) in performance for that sport or event.

Variation in performance is calculated as the standard deviation of repeated performances by an individual athlete (within-subject standard deviation). Hopkins (1999) defines that individual variation of an athlete's competitive performance as the typical error in performance or simply the Typical Error. As sport scientists we are interested in Typical Error to quantify the smallest worthwhile change that is beneficial (or harmful) to the athlete. Hopkins (1999) has shown via statistical modelling that an improvement in performance equal to half an athletes Typical Error will result in around 10% more wins than usual.

Paton & Hopkins (2006) have previously studied variation in track cycling performance, in a broader study of cycling performance times. Using two years of the United States men's national Kilo (1km) time-trial series as their representation of track cycling they found that the Typical Error for time in the Kilo was 1.0% (0.8 – 1.4 95% CL). This suggests the smallest worthwhile change for a track athlete maybe as little as 0.5%. However their study was limited by the use of only one track event, which differs from other track events involving other distances, flying starts (200 m sprints), pacing strategies (pursuit) and teamwork (team pursuit). In addition the authors did not investigate the variation of female track cyclists nor cyclists of international quality.

This study aimed to quantify the Typical Error as a Coefficient of Variation (CV) in the performance times of internationally elite competitive track cyclists and expand on the findings of Paton & Hopkins (2006). The results will be related to power so coaches and sport scientists can determine the smallest worthwhile changes in power required to deem a training or sport science intervention as successful.

METHODS: Data Collection: Results from the four 2005/06 UCI World Cups, the 2006 World Championships and the 2006 Commonwealth Games were obtained from their respective websites (www.uci.ch and www.melbourne2006.com.au). Seven events were selected for analysis. They were: Men's and Women's Sprint qualification round (200m);

Women's 500m TT; Men's Kilo (1 km TT); Women's 3km Individual Pursuit; Men's 4km Individual Pursuit; and Men's 4km Team Pursuit. Cyclists who did not compete in three or more races were discarded from the analysis in order to keep the CV calculation exact as outlined in Hopkins *et al*. (2001).

Data Analysis: Once collated in MS Excel 2003 the times were log-transformed. This made it easier to express the resulting Typical Error as a percentage (CV) and accounts for skewness typically seen in timed athletic data. SPSS v13 was used to analyse the log times using a two-way ANOVA (Cyclist*Race). The ANOVA was not used to calculate significant differences. Rather the RMSE from the ANOVA table was back transformed to give a coefficient of variation of performance time as a percentage (Hopkins, 2000), that is, the average typical error for that event. The 95% confidence limit was calculated using the total degrees of freedom in the ANOVA and the Chi-squared distribution (Hopkins, 2000).

To express Typical Error as a percentage of Mean Power the relationship developed in Hopkins *et al.* (2001) was used. In that paper they derived that the typical error in mean power is equal to three times the typical error of cycling velocity. That derived relationship was validated by modeling power over a range of velocities for two 'virtual cyclists' riding at conditions typical to a dry warm indoor track at sea level. The model from Martin *et al*. (2006) was used to calculate power, where ρ is air density calculated from air temperature, humidity and pressure; C_{Drag} is the coefficient of aerodynamic drag for the cyclists; V is velocity; m is mass; g is gravity; C_{Roll} is the typical rolling resistance for a racing tubular tire on a wooden track

$$\text{Modeled Power (P)} = 0.5 \times \rho \times C_{Drag} \times V^3 + m \times g \times C_{Roll} \times V$$

The typical cyclists were modeled on data collected from two real male and female pursuit cyclists who have competed at UCI World Cups. Both cyclists had carried out an aerodynamic test to calculate C_{Drag} either in the field using SRMs and regression analysis or in a wind tunnel. The C_{Roll} value was an average value for a tubular tire chosen from the literature (Martin & Cobb, 2002). The velocities modeled represented the typical range of velocities by elite cyclists. For example the highest velocity used for the male and female cyclist would break their current respective Individual Pursuit world records by around 5 seconds. The lowest velocity would have been good enough to win gold in the respective Individual Pursuit at the 2007 South East Asian Games.

RESULTS: The cyclists used in this study all posted times typical of elite international cyclist. Figure 1 displays the CV (± 95% CL) for each event. The average Typical Error for all events over the 2005/06 UCI track season was 1.0%. The results of modeling percent change in power for an increase in cycling velocity suggest that a 1% increase in velocity is equal to 2.89 - 2.94% increase in mean power. There was however some evidence that this ratio increased as velocity increased through the typical race paces and when other factors of the model, such as air density and drag coefficients were modified. However the largest increase observed was about 0.03%.

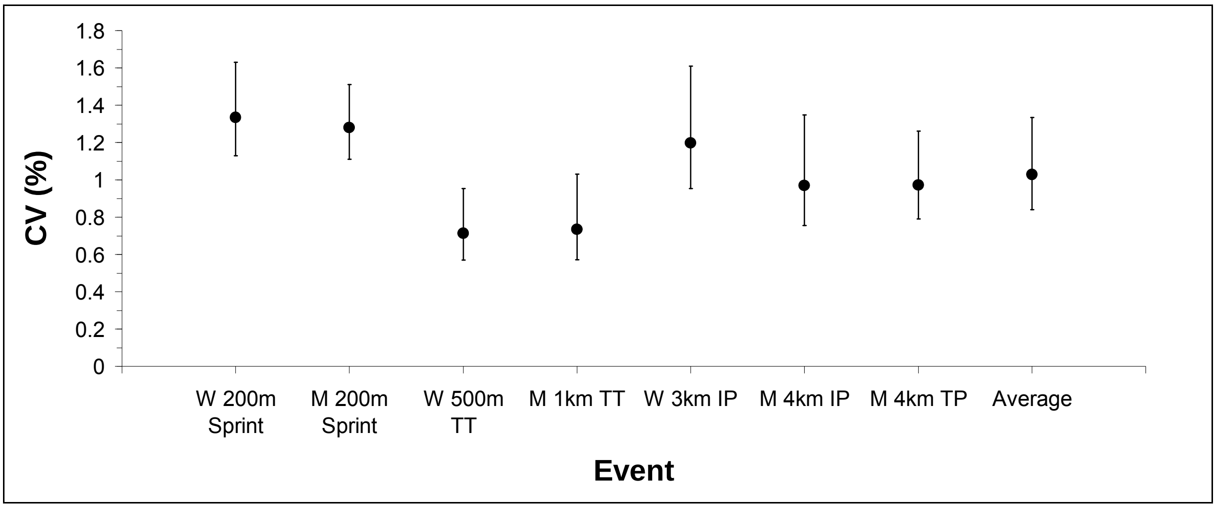

Figure 1: CV (±95% CL) for each event

DISCUSSION: The average Typical Error for all track events in this study (1%) is identical to the Typical Error for the Kilo race series calculated by Paton & Hopkins (2006). However, their Typical Error for the Mens Kilo is 1.4 (0.9 – 2.1 95% CL) times greater than the 0.7% (0.6 – 1.0 95%CL) observed for Mens Kilo in this study. Given that the cyclists in their study were nearly 5 seconds slower, on average, than those in the present study (64 vs. 69 seconds) the results may indicate that less talented cyclists are more variable in their performance. However it should be noted they used a mixed modeling procedure rather than the ANOVA approach I used. Further, the Typical Error measured in this study is a gross measure of within-cyclist variation over the entire season. Other sources of variation in the present study include: pacing strategies; changing fitness during the season; motivation for events like the World Champs; using different equipment during the season; altered riding position between events (changing aerodynamic drag). Future study is needed under controlled conditions to determine if less talented cyclists have more variation in their performance.

From the relationship derived by Hopkins (2001), a 1% change in performance time should equate to 3% change in mean power during a steady pace effort. This modeling approach assumes a constant power output, which is somewhat unrealistic and further validation is required using actual measured velocity profiles from real cyclists. While still anecdotal, by modeling a typical male and female pursuit cyclist over a range of race velocities it appears that the ratio of percentage change in power for a given percentage change in velocity (or time) is indeed close to 3 to 1 .

The most important application of these findings is in assessing improvements in competitive performance and physiological tests or the success of changes made to the rider position through aerodynamic testing. When performance is measured in time we simply find the percentage difference between two most recent performances (or the most recent performance and the average performance). If that percentage difference is greater than half the Typical Error for that cyclist's event (from figure 1), then we assume there is some meaningful effect (beneficial or harmful) occurring (Hopkins, 1999). Where the performance is measured in average power we again calculate the percentage difference of power between two performances. However we assume there is some meaningful effect (beneficial or harmful) occurring when that percentage difference is greater than 1.5 times the Typical Error for that cyclist's event (from figure 1). Using 1.5 as a multiplier of Typical Error will convert the smallest worthwhile change from time to power.

In a physiological or aerodynamic test by knowing the smallest worthwhile change in power (half of the Typical Error) and the Typical Error of the test (also as a CV of power), we can judge whether the test is sensitive enough to detect the smallest worthwhile improvement in performance. From the average Typical Error of the track cyclists in this study if test error < 1.5% then it probably will detect the smallest worthwhile change. If test error ≈ 1.5% it may detect the smallest worthwhile change provided multiple trials are conducted. If test error > 1.5% then the test probably will not detect the smallest worthwhile change.

CONCLUSION:

- The average typical variation in the performance time of Elite Track Cyclists is 1.0% (0.8 – 1.3 95% CL).
- The typical variation in average power of Elite Track Cyclists during a race is around 3 times the typical variation of performance time or 3%.
- The smallest worthwhile enhancement in performance time is about 0.5% in the performance time of Elite Track Cyclists for various track events.
- The smallest worthwhile enhancement in average power of Elite Track Cyclists during a physiological or aerodynamic test (field or lab) is about 1.5%.
- A physiological or aerodynamic test (field or lab) should have a test-retest reliability CV < 1. 5% to detect the smallest worthwhile change in power.

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