EFFECT OF DYNAMICALLY-WEIGHTED WHEEL IN ROLL-DOWN STUDY

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INTRODUCTION

A dynamically-weighted wheel (DWW) is one in which the wheel's moment of inertia is changed in a controlled manner as the rotational speed of the wheel changes. Although first-order principles of physics may suggest such a wheel would provide no benefit, it is theorized that many benefits may accrue in fact, such as differential effects due to bicyclist drag. If so, such a wheel may be especially advantageous in time trials /triathlons over rolling terrain.

Here, the following three hypotheses were conjectured and formed the basis of a roll-down study:

H1 *Potential energy effect*. From a standstill, DWW accelerates down a hill at a similar rate to an equivalent standard wheel (SW) even though the moment of inertia increases as speed increases.
H2 *Added momentum effect*. For a period, a DWW maintains a higher average speed coming out of a high speed downhill slope as compared to an equivalent SW.
H3 *Figure skater effect.* As a DWW slows down and the moment of inertia decreases, the wheel maintains a higher speed as compared to an equivalent SW.

METHODS

Two hills in the Skaneateles, NY, region were used for the study. In this abstract, we confine our attention to course 2 (but we note that the results for course 1, used to test H1, was consistent with H1).

One rider, using a Trek Hilo 1000 (Tri) bike, performed all the runs. In each run, the rider started on a minor downhill incline (about 3 %) near the top of the hill and coasted down the hill on precisely the same line. The wheels used were either Rolf Vector Pro's (bladed spokes, 30mm deep section), which served as the SW's; or Rolf Vector's in a standard configuration (20mm deep section with round spokes) that were converted to DWW's as follows. For the rear wheel, six 1 oz weights that slide along spokes were calibrated (using elastic bands) to be "out" (out to the rim) at 24 mph and "in" at approximately 22 mph. Another six ¾ oz weights were calibrated to be out at 18 mph and in at approximately 17mph) mph. The 1oz and ¾ oz weights were alternated around the wheel in a balanced way. (A duplicate Pro wheel was not available for the study and so the standard configuration was chosen as a conservative option.) Eight runs were made with each wheel set. For convenience, each wheel set was run twice (denoted as a *run pair*) before switching to the other set. All other controllable variables (tires (Michelin Race Pro 2), tubes, tire pressure, rider position) were held constant.

An SRM Power meter (PRO version) system was used to record speed (0.5 sec intervals) and a Ciclosport HAC5 was used to record altitude (2 sec intervals).

RESULTS AND DISCUSSION

The average speed for each wheel set is displayed versus time in Figure 2. (A plot of speed versus distance, while technically better, would produce similar results.) Altitude information is also included.

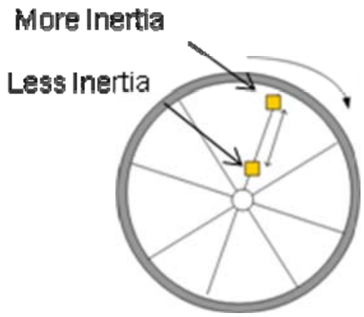

Figure 1: Schematic of one form of a DWW.

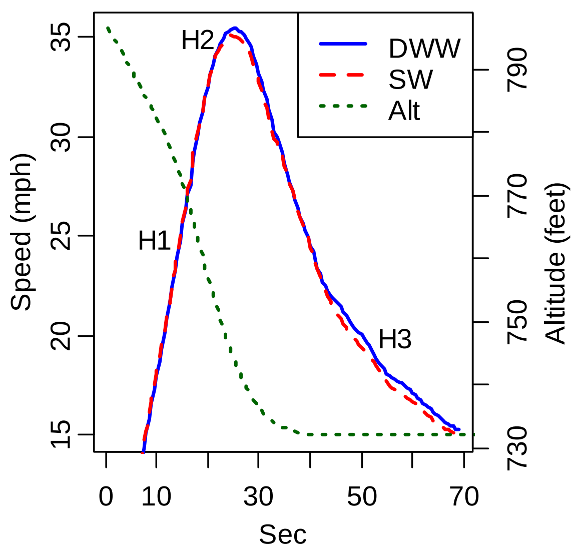

Figure 2: DWW and SW Speeds (Means of 8 Runs) versus Time, with Information on Altitude and Regions to test Hypotheses 1 to 3.

This figure suggests that each of H1 (potential energy effect—no difference between DWW and SW), H2 (added momentum effect—DWW outperforms SW), and H3 (figure skater effect—DWW outperforms SW) are consistent with the results of the study.

To examine this more carefully, the 8 instantaneous speeds for each wheel set were examined at each 0.5 sec interval of readings. At each such point in time, the difference $\bar{D}$ in sample means between DWW and SW was calculated, the sample variances of run pairs were pooled (8 d.f.) to form a standard deviation s_p, and this was used to create a nominal 95% confidence interval ($\bar{D} \pm 2.31 s_p \sqrt{2/8}$). This method for finding s_p may be slightly optimistic; however, there was some statistical evidence of non-stable conditions during the course of the study, and so this method was used. (Statistical designs such as blocks of 2×2 Latin Squares could be used in larger studies to mitigate the effect of changing conditions while still providing an accurate estimate of variation.)

These results are shown in Figure 3.

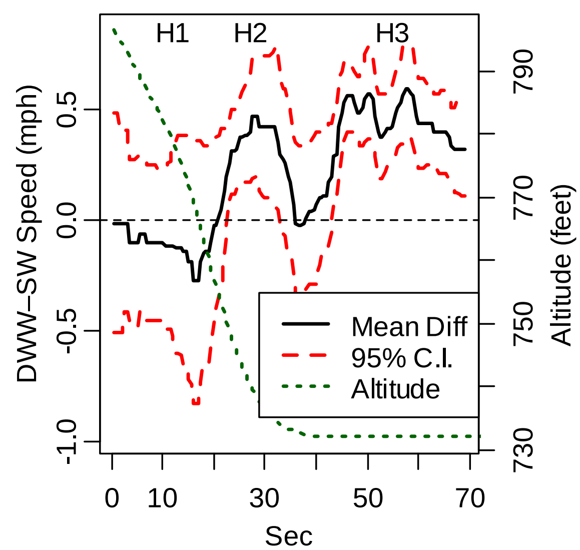

Figure 3: Difference between DWW and SW Speeds (Means of 8 Runs) versus Time, and Nominal 95% Confidence Intervals, along with Information on Altitude and Regions, to test Hypotheses 1 to 3.

This figure suggests that these data are in agreement with all three hypotheses. In the H1 region, no differences were detected in mean speeds, while in the H2 and H3 regions, there is evidence that the DWW outperformed the SW.

SUMMARY/CONCLUSIONS

There is evidence from this small study that a DWW can outperform an equivalent SW. Future studies will focus on determining the optimal dynamic weight/ band tension ratio for a given course profile and rider ability.