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Conference Abstract

Power loss of the chain drive in tandem bicycles

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Abstract:

Introduction**:** Tandem cycling is a Paralympic sport, in which two cyclists ride on one tandem bicycle. The front rider (pilot), is responsible for the steering, braking, changing gears, and tactics. The back rider (stoker), has a visual impairment and is responsible for responding to changes in cadence and generating power. As the average difference in finish time between obtaining a medal and becoming 4th was 0.5% at the Tokyo 2020 Paralympics for tandem cycling track and road time trial events, much time and effort in the competitive preparation is focused on enhancing individual and team performance. One way to increase performance is by minimizing power losses of the chain drive, which consists of two chains in tandem cycling, the primary and secondary chain. This study aimed to determine the mechanical power loss due to the chain drive of a race tandem bicycle and whether power losses in the chain drive are different for the pilot and stoker. Also, the effect of chain wheel size on power loss was studied.

Methods: The tests were performed on a tandem bicycle to assess power losses in the chain drive by applying a fixed power input to of the cranks with an electric motor and measuring the power output at the location of the rear wheel. This was done at the rear crank without the secondary chain to simulate a solo bicycle, and with the primary and secondary chain attached to the rear crank to simulate power input only by the stoker on a tandem. The power input was also delivered to the front crank using both primary and secondary chains to simulate power input only by the pilot. In each situation, gears 53-11 and 53-13 were used.

Results: Power losses in the chain drive were significantly affected by bicycle type and the position of the tandem cyclist ($p<0.001$). Results showed that the power loss in the solo bicycle (mean power loss = 1.9% ±1.5%) was significantly less than at the tandem stoker (3.7% ±2.4%, $p<0.001$) and pilot (3.0% ±1.8%, $p<0.001$), with a significant difference between pilot and stoker ($p<0.001$). However, these differences between pilot and stoker were only present at a power output below ~250W. Results also showed that in tandem bicycles a gear ratio of 53-11 (mean power loss = 4.0% ±2.8%) resulted in a higher power loss than 53-13 (2.9% ±1.7%; $p<0.001$).

Conclusion: Power loss due the chain drive in tandem cycling is higher than in solo cycling. It is affected by the chain wheel size, with a larger chain wheel resulting in a lower power loss. It is also affected by the location of the power input, with the location of the pilot resulting in a lower power loss than that of the stoker, although only for the lower power zones.

Keywords: transmission efficiency, para-cycling, power output