A mathematical model for optimal breakaways in cycling: balancing energy expenditure and crash risk: a supplementary report

Naledi Oyelaran, Naledi Tembo, Ravi Mehta

We present a mathematical model for optimizing breakaway strategies in competitive cycling, balancing power expenditure, aerodynamic drag and crashing. Our framework incorporates probabilistic crash dynamics, allowing a cyclist's risk tolerance to shape optimal tactics. We define an objective function that accounts for both finish time differences and the probability of crashing, which we optimize subject to an energy expenditure constraint. We demonstrate the methodology for a flat stage with a simple constant-power breakaway. We then extend this analysis to account for fatigue-driven power decay and varying terrain and race conditions. We highlight the importance of strategy by demonstrating that carefully planned decision making can lead to a race win even when the energy expenditure is low. Our results highlight and quantify the fact that, at the elite level, success often depends as much on minimizing risk as on maximizing physical output.

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