

Cycling Performance Optimization, A New Telemetry System to Study Tire Inflation Pressure

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Abstract

This study investigated the relationship between tire inflation pressure (ranging from 4 to 10 bar) and rolling resistance force to optimize cycling performance at a concrete velodrome, using a new low-cost telemetry system also the aerodynamic coefficient in real-time. Results revealed significant differences between pressures up to $\pm 9\%$ absolute power to maintain the same speed, while the aerodynamic coefficient remained stable. Concluding that using telemetry to determine ideal pressure settings can significantly improve mechanical efficiency and overall athlete performance.

Keywords

advanced analysis; signals; data; cyclists

1 Introduction

In cycling, the analysis of the forces acting on the cyclist-bicycle system [CBS] is key to optimizing performance (1). Rolling resistance [RRF] is one of these forces, influenced by various factors, including tire inflation pressure (2). This study describes the development and implementation of a low-cost telemetry system, aimed at real-time

monitoring of variables during cycling practice, in order to evaluate the effect of inflation pressure on RRF under real-world conditions (3). The main objective is to describe the relationship between tire inflation pressure and RRF, to determine the optimal pressure, in order to optimize cyclist's mechanical efficiency and, consequently, their performance.



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2 Material and Methods

A cyclist at the Zaragoza velodrome performed 71 one-kilometer trials, all recorded under similar weather conditions. Six different inflation pressures [4, 5, 6, 7, 8, and 10 bar] were tested using 25mm Continental Gator Skin tires. A pedal-based power meter from Favero [Favero Electronics SRL, Arcade TV, Italy] and a magnetic speed sensor were installed on the cyclist's bike, along with a weather station [Kestrel Meter 5500, NK Company, USA] to measure air density, and a digital scale to record CBS weight [72.38 kg]. The new developed telemetry system captured and synchronized sensors data in real time, applying a linear regression model instantly for each pressure value to calculate the RRF and aerodynamic coefficient [CdA]. After the trials, quadratic regressions analysed the relationship between pressure and RRF. In addition, ANOVA and Student's t-tests determined the statistical significance between the different pressure conditions.

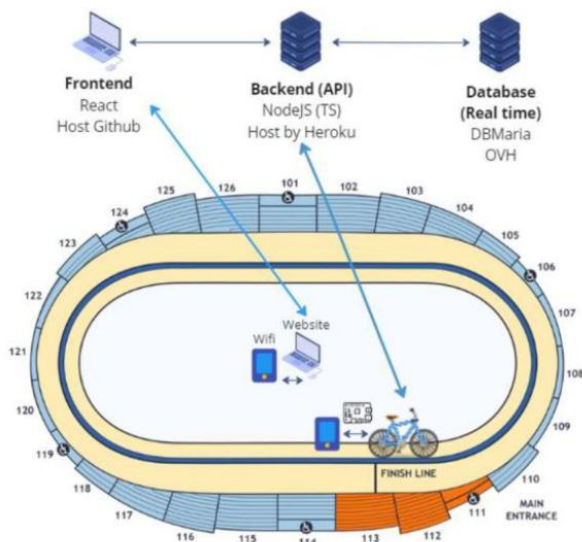


Figure 1. Structure and data flow of the bicycle monitoring system

3 Results

The analysis observed a quadratic relationship with a high goodness-of-fit [$R^2 = 0.9413$]. The lowest RRF values appeared at intermediate pressures of 6, 7, and 8 bar, while both the lowest [4 and 5 bar] and highest [10 bar] pressures showed significantly higher RRF values. These differences resulted in up to 9% more absolute power required by the cyclist to maintain the same speed. The CdA remained stable throughout the study [CV = 2.62%].

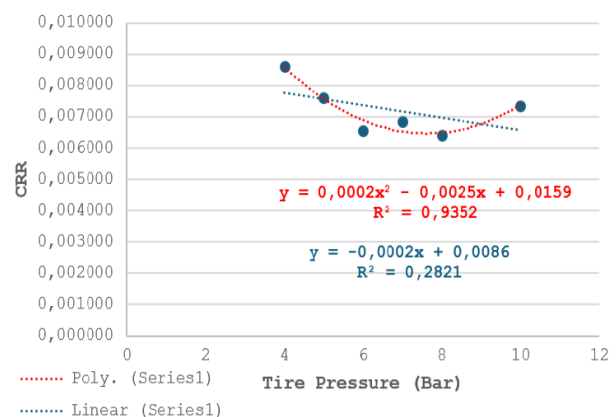


Figure 2. Relationship between RRF (N) and pressure (bar) at the average cycling speed of 8.83 m/s. Linear adjustment (blue) and quadratic adjustment (red).

4 Conclusions

This study highlights the significant influence of tire inflation pressure on rolling resistance, revealing a quadratic and not a linear relationship when tested on real surfaces with some roughness. Practical applications involve using low-cost telemetry systems to determine the optimal tire pressure for each cyclist based on surface characteristics, thereby reducing RRF and improving efficiency and performance. Future research can replicate this study testing different surface roughness and tire types.

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