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Reliability of power meter calibration by mathematical modelling of treadmill cycling

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Abstract

New power meters that are installed on various parts of the bike entered the market recently. Calibration of power meters is essential to ensure correct power output readings for testing and training. The use of a dynamic calibration rig was proposed as the preferred method to calibrate cycle ergometers (Woods et al., 1994: International Journal of Sports Medicine, 15(4), 168-171). While this works for power meters that measure power output after its transmission through the crank axle, it is not suitable for systems installed on the pedals or the crank arm (e.g. Garmin Vector, Kéo Power, Stages, Rotor Power). Therefore, we want to propose a new method to dynamically calibrate all available power meters. The purpose of our study was to quantify the typical error of this method used to assess load characteristics of power meters.

Thirty power meters (14 SRM, 8 Powertap, 5 Quarq, 3 Garmin Vector) mainly used by cyclists of the Swiss national mountain bike team were analysed. Each cyclist rode his own bike equipped with his power meter on a motorized treadmill (Poma, Dürrröhrsdorf-Dittersbach, Germany), after executing all calibration procedures according to the manufacturer. Cyclists rode with a velocity v = 3.5 m s-1 at an inclination of α1 = 1° and α2 = 7°. These corresponded to power demands of approximately 1 W kg-1 and 5 W kg^{-1}, respectively. Power output measurements were averaged over 1 min for both inclinations. The total mass m of the cyclist, his equipment and bike was measured on a calibrated scale (Model 861, Seca, Reinach, Switzerland). To eliminate any contribution of rolling or aerodynamic resistance, the difference in power output between the two inclinations was calculated as ΔP = m · g · v · (sinα2 – sinα1). The ratio between the measured difference and that calculated by the mathematical model was defined as the load characteristic of the power meter. A value of 1 indicates perfect agreement between the measurement and the model. The procedure was performed twice. The typical error of measurement and its 95% confidence interval for the load characteristic was calculated from the 30 repeated trials (Hopkins, 2000: Sports Medicine, 30(1), 1-15).

The typical error for the load characteristic was 1.5% with a 95% confidence interval of 1.1% to 1.9%. The change in the mean from trial 1 to trial 2 was 0.1% with a 95% confidence interval of -0.7% to 0.9%.

The typical error of 1.5% demonstrates a high reliability of the method used to assess the load characteristic of a power meter, which can easily be enhanced by performing multiple trials. The value for a convenient triple measurement follows as 1.5% / 31/2 = 0.9% (Hopkins, 2000). The typical error presented here is comparable to the reliability reported for the calibration with a dynamic calibration rig (Woods et al., 1994). Our calibration method is easy to administer, time efficient and independent of the power meter system, rolling resistance or cyclist riding style. Even though the method does not assess absolute power output readings, it detects systematic measurement error. To further evaluate the load characteristic, an assumption concerning the drivetrain loss is necessary. After personal communication with J. Smith (www.friction-facts.com, December 6, 2013), we assume a drivetrain loss of 2% in power output difference scores. A valid system located on the crank would therefore measure a 2% higher difference in power output than predicted by the mathematical model. We conclude, that calibrating power meters by mathematical modelling of treadmill cycling is highly reliable and convenient.

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Received: 1 May 2014. Accepted: 1 June 2014.