

## The Effects of Training on Cycling Efficiency

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Gross efficiency, defined as the ratio of work generated to the total metabolic energy cost, has been suggested to be a key determinant of endurance cycling performance [1-3]. Some consideration of the factors that influence cycling efficiency (e.g. muscle fibre type) has been given [1]. However, several fundamental assumptions related to the importance of cycling efficiency have received very little experimental verification. One such factor is whether efficiency can be improved by training. Historically, the majority of evidence investigating the influence of training on cycling efficiency has been largely cross sectional in nature and has failed to establish differences between trained and untrained cyclists [4-8]. However, the majority of these studies can be criticized on the basis of their methods and a failure to address the risk of committing type 2 statistical errors. Additionally, the use of cross-sectional study designs fails to identify whether differences in efficiency between trained and untrained populations are accounted for by inherited genetic factors, or training related effects.

Recently, the use of longitudinal study designs is providing growing evidence for the possibility of increasing cycling efficiency via training [9-12]. Specifically, this research has demonstrated that efficiency can be improved over the course of one [10], or multiple cycling seasons [12]. In these studies, the increases in cycling efficiency were significantly correlated with the volume and intensity of training completed. Moreover, subsequent research has further suggested that high intensity training might provide the most potent stimulus for improving cycling efficiency [11]. Interestingly, although this high intensity training approach improves cycling efficiency, it does not cause a change in  $VO_{2max}$  in trained cyclists. Indeed, an inverse relationship between cycling efficiency and  $VO_{2max}$  appears to exist [13]. Cyclists with a high  $VO_{2max}$  seem to be less responsive to training related changes in cycling efficiency than those with a lower  $VO_{2max}$  [13].

Even though the studies outlined above have demonstrated that gross efficiency can increase as a result of training, it is still unclear whether such chronic changes will actually impact on performance. Currently, the effect of training-induced increases in efficiency on cycling performance has not been assessed. Additionally, the physiological mechanisms related to training improvements in cycling efficiency and those related to the development of the observed inverse relationship with  $\rm VO_{2max}$ , remain to be fully elucidated. Even though not directly related to exercise training, short-term nitrate supplementation has been shown to produce a similar efficiency VO<sub>2max</sub> response as those described in the training studies above. This contemporary area of research suggests that nitrate affects mitochondrial function, increasing the number of molecules of ATP generated per atom of oxygen consumed (the P/O ratio) and therefore, mitochondrial efficiency [14]. Indeed, high levels of circulating nitrate have been found in high altitude natives, who also display significantly lower VO<sub>2</sub> at submaximal work rates (i.e. higher cycling efficiency), lower  $\dot{VO}_{2max}$  values than sea-level inhabitants [15,16]. Thus, it might be speculated that training leads to a natural increase in the body's nitrate levels, although future research is warranted to test this hypothesis.

## References

- Coyle EF, Sidossis LS, Horowitz JF, Beltz JD (1992) Cycling efficiency is related to the percentage of type I muscle fibers. Med Sci Sports Exerc 24: 782–788.
- Horowitz JF, Sidossis LS, Coyle EF (1994) High efficiency of type I muscle fibers improves performance. Int J Sports Med 15: 152–157.
- Joyner MJ, Coyle EF (2008) Endurance exercise performance: the physiology of champions. J Physiol 586: 35–44.
- Boning D, Gonen Y, Maassen N (1984) Relationship between work load, pedal frequency, and physical fitness. Int J Sports Med 5: 92–97.
- Marsh AP, Martin PE (1993) The association between cycling experience and preferred and most economical cadences. Med Sci Sports Exerc 25: 1269– 1274.
- Marsh AP, Martin PE, Foley KO (2000) Effect of cadence, cycling experience, and aerobic power on delta efficiency during cycling. Med Sci Sports Exerc 32: 1630–1634.
- Moseley L, Achten J, Martin JC, Jeukendrup AE (2004) No differences in cycling efficiency between world-class and recreational cyclists. Int J Sports Med 25: 374–379.
- Nickleberry BL, Brooks GA (1996) No effect of cycling experience on leg cycle ergometer efficiency. Med Sci Sports Exerc 28: 1396–1401.
- Hopker JG, Coleman DA, Wiles JD (2007) Differences in efficiency between trained and recreational cyclists. Appl Physiol Nutr Metab 32: 1036–1042.
- Hopker J, Coleman D, Passfield L (2009) Changes in cycling efficiency during a competitive season. Med Sci Sports Exerc 41: 912–919.
- Hopker J, Coleman D, Passfield L, Wiles J (2010) The effect of training volume and intensity on competitive cyclists' efficiency. Appl Physiol Nutr Metab 35: 17–22.
- Santalla A, Naranjo J, Terrados N (2009) Muscle efficiency improves over time in world-class cyclists. Med Sci Sports Exerc 41: 1096–1101.
- Hopker JG, Jobson SA, Coleman D, Passfield L (2012) Inverse relationship between VO<sub>2max</sub> and gross efficiency. Int J Sports Med, In press.
- Larson FJ, Schiffer TA, Borniquel S, Sahlin K, Ekblom B, et al. (2011) Dietary inorganic nitrate improves mitochondrial efficiency in humans. Cell Metab 13: 149–159.
- Erzurum SC, Ghosh S, Janocha AJ, Xu W, Bauer S, et al. (2007) Higher blood flow and circulating NO products offset high-altitude hypoxia among Tibetans. Proc Natl Acad Sci USA 104: 17593–17598.
- 16. Ge RL, Chen QH, Wang LH, Gen D, Yang P, et al. (1994) Higher exercise performance and lower  $\dot{VO}_{2max}$  in Tibetan than Han residents at 4,700 m altitude. J Appl Physiol 77: 684–691.

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