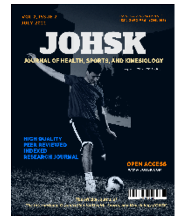
Journal of Health, Sports, and Kinesiology, 2021, 2(2), 4-7

Literature Review **Open Access**

Article History:
Received 20 September 2020
Accepted 23 October 2020
Published 1 August 2021
Available online 30 July 2021
https://doi.org/10.47544/johsk.2021.2.2.4

Corresponding Author:
Boram Lim
boram.lim@unlv.edu
Department of Kinesiology & Nutrition Sciences
School of Integrated Health Sciences
University of Nevada, Las Vegas, USA



The Effect of Crank Arm Length on Cycling Economy and Performance in Triathlon

Boram Lim & John A. Mercer
University of Nevada, Las Vegas, USA

Keywords: cycling kinematics, cycling kinetics, cycling time trials, crank arm length

Introduction

Given the nature of a triathlon race, the cycling distance is typically much longer than swimming and running across race distances from sprint to Ironman. Besides, triathletes should try to not only maintain a certain level of cycling power but also consider cycling economy to make a better performance in both the cycling portion and the overall race (Bonacci et al., 2013; Sleivert & Rowland, 1996; Swinnen et al., 2018). The cycling economy is an important indicator to predict cycling performance in terms of time to complete a certain distance. Both cycling economy and performance are determined by the interaction between mechanical output and physiological input (Barratt et al., 2016; Korff et al., 2007; Sunde et al., 2010). Theoretically, improving cycling economy elicits a better cycling time trial performance and/or less physiological demands (e.g., rate of oxygen consumption: VO_2, heart rate) to complete at a given distance. The crank arm length (CAL) is one of the important factors among many variables that affect the economy and performance in cycling (McDaniel et al., 2002). Therefore, the appropriate selection of CAL may play a key role in improving the cycling portion of the race and entire triathlon performance. The purpose of this review is to identify the effects of acute changing CAL on physiological and biomechanical responses during cycling.

Overview

Previous researchers have reported changing of CAL affect cycling power production (MacDermid & Edwards, 2010; Martin & Spirduso, 2001; Too & Landwer, 2000), lower limb joint angle, cadence (Barratt et al., 2011 & 2016; Candotti et al., 2007; Christiansen et al., 2013), pedal torque (Hull & Gonzalez, 1988), lower limb muscle activity (Watanabe, 2020), and VO_2 (Ferrer-Roca et al., 2017; Morris & Londeree, 1997).

The effect of different CALs on cycling power, lower extremity joint kinematics, and kinetics during such a short duration (~30 seconds) with supramaximal effort have been well documented (Barratt et al., 2011; Christiansen et al., 2013; MacDermid & Edwards, 2010; Martin & Spirduso, 2001; Too & Landwer, 2000; Watanabe, 2020). There is also a strong body of research that provides insight into the physiological and biomechanical responses according to acute changing of CALs at the constant work rate during submaximal cycling intensity (Barratt et al., 2016; Ferrer-Roca et al., 2017; Hull & Gonzalez, 1988; Korff et al., 2007; McDaniel et al., 2002).

Some researchers have recommended using shorter CAL than conventional lengths (165~175mm) for generating more cycling power (Barratt et al., 2016; Hull & Gonzalez, 1988; Inbar et al., 1983). Ferrer-Roca et al. (2017) revealed the tendency of increasing hip and knee range of motion and hip extensor moment with a longer CAL than preferred CAL. However, other studies have been reported that there were no significant differences in cycling power, joint angle, and $\dot{V}O_2$ depends on when using different CALs (Barratt et al., 2011; Inbar et al., 1983; MacDermid & Edwards, 2010; McDaniel et al., 2002; Morris & Londeree, 1997; Watanabe, 2020). Furthermore, previous studies were limited in the type of subject recruited either elite or well-trained cyclists (Barratt et al., 2011 & 2016; Christiansen et al., 2013; Korff et al., 2007; MacDermid & Edwards, 2010; Martin & Spirduso, 2001; McDaniel et al., 2002; Morris & Londeree, 1997) or young healthy students (Ferrer-Roca et al., 2017; Hull & Gonzalez, 1988; Inbar et al., 1983; Too & Landwer, 2000; Watanabe, 2020).

Some researchers have recommended using shorter CAL than conventional lengths (165~175mm) for generating more cycling power (Barratt et al., 2016; Hull & Gonzalez, 1988; Inbar et al., 1983). Ferrer-Roca et al. (2017) revealed the tendency of increasing hip and knee range of motion and hip extensor moment with a longer CAL than preferred CAL. However, other studies have been reported that there were no significant differences in cycling power, joint angle, and $\dot{V}O_2$ depends on when using different CALs (Barratt et al., 2011; Inbar et al., 1983; MacDermid & Edwards, 2010; McDaniel et al., 2002; Morris & Londeree, 1997; Watanabe, 2020). Furthermore, previous studies were limited in the type of subject recruited either elite or well-trained cyclists (Barratt et al., 2011 & 2016; Christiansen et al., 2013; Korff et al., 2007; MacDermid & Edwards, 2010; Martin & Spirduso, 2001; McDaniel et al., 2002; Morris & Londeree, 1997) or young healthy students (Ferrer-Roca et al., 2017; Hull & Gonzalez, 1988; Inbar et al., 1983; Too & Landwer, 2000; Watanabe, 2020).

Considerations

In this review, we focused on the effect of the acute changing of CAL on cycling. Even though ample research has been conducted to investigate the relationship between cycling performance and CAL in both biomechanics and exercise physiology perspectives, the effects of changing CAL on cycling time trial performance still remains unclear.

Previous studies showed inconsistent results regarding the effect of changing CAL in cycling mechanic and physiological parameters. Increasing power output in a short duration may not a good indicator of cycling time trial performance. In terms of successful endurance cycling, the strategy to apply propulsion forces effectively over a long duration is more important than achieving a higher power output in a short amount of time. Furthermore, the maximum cycling power test mainly relies on anaerobic capacity (i.e., phosphagen & anaerobic glycolytic system); however, aerobic metabolism is a major energy source during endurance cycling from 80% up to 99% (Sunde et al., 2010). Therefore, the functional threshold power (FTP) test may be a better predictor of endurance cycling performance than the maximum power test in a short duration (Sørensen et al., 2019).

Besides, a large range of CALs (110 to 265mm) was used for several studies that were impractical to use for cycling training and real race event. Based on the review of literature, the well-trained triathletes/cyclists could maintain approximately the same amount of cycling power output and $\dot{V}O_2$ across different CALs (Barratt et al., 2011; Watanabe, 2020). However, the changing of CALs may have more influence on the cycling economy and performance to novice triathletes/cyclists.

Research by Martin and Spirduso (2001) demonstrated that the ratio between CAL and lower limb length for the maximal power production was 20% of leg length and 41% of tibia length, respectively. Also, this study showed an inverse relationship between cadence and speed depends on increasing CALs. Therefore, the aged group or novice triathletes should choose an appropriate CAL based on their lower limb length, cycling technique, and race strategies for better race performance.

From these points of view, more research is needed about the effect of CAL in a standard range (165 ~ 175mm) on endurance cycling performance as an aspect of both biomechanical and physiological parameters. Also, future research will be testing the reliability of the effect of CAL on cycling mechanics and power output between the laboratory setting and overground.

References

Barratt, P. R., Korff, T., Elmer, S. J., & Martin, J. C. (2011). Effect of crank length on joint-specific power during maximal cycling. *Medicine and Science in Sports and Exercise*, *43*(9), 1689–1697. https://doi.org/10.1249/mss.0b013e3182125e96

Barratt, P. R., Martin, J. C., Elmer, S. J., & Korff, T. (2016). Effects of pedal speed and crank length on pedaling mechanics during submaximal cycling. *Medicine and Science in Sports and Exercise*, *48*(4), 705–713. https://doi.org/10.1249/MSS.0000000000000817

Bonacci, J., Vleck, V., Saunders, P. U., Blanch, P., & Vicenzino, B. (2013). Rating of perceived exertion during cycling is associated with subsequent running economy in triathletes. *Journal of Science and Medicine in Sport*, *16*(1), 49–53. https://doi.org/10.1016/j.jsams.2012.04.002

Candotti, C. T., Ribeiro, J., Soares, D. P., De Oliveira, Á. R., Loss, J. F., & Guimarães, A. C. S. (2007). Effective force and economy of triathletes and cyclists. *Sports Biomechanics*, *6*(1), 31–43. https://doi.org/10.1080/14763140601058490

Christiansen, C., Bradshaw, E. J., & Wilson, C. (2013). Optimal Crank Arm Length and Body Position for Road Sprint Cycling Performance. *Journal of Chemical Information and Modeling*, *53*(9), 1689–1699. https://doi.org/10.1017/CBO9781107415324.004

Ferrer-Roca, V., Rivero-Palomo, V., Ogueta-Alday, A., Rodríguez-Marroyo, J. A., & García-López, J. (2017). Acute effects of small changes in crank length on gross efficiency and pedalling technique during submaximal cycling. *Journal of Sports Sciences*, *35*(14), 1328–1335. https://doi.org/10.1080/02640414.2016.1215490

Hull, M. L., & Gonzalez, H. (1988). Bivariate optimization of pedalling rate and crank arm length in cycling. *Journal of Biomechanics*, *21*(10), 839–849. https://doi.org/10.1016/0021-9290(88)90016-4

Inbar, O., Dotan, R., Trousil, T., & Dvtr, Z. (1983). The effect of bicycle crank-length variation upon power performance. *Ergonomics*, *26*(12), 1139–1146. https://doi.org/10.1080/00140138308963449

Korff, T., Romer, L. M., Mayhew, I., & Martin, J. C. (2007). Effect of pedaling technique on mechanical effectiveness and efficiency in cyclists. *Medicine and Science in Sports and Exercise*, *39*(6), 991–995. https://doi.org/10.1249/mss.0b013e318043a235

MacDermid, P. W., & Edwards, A. M. (2010). Influence of crank length on cycle ergometry performance of well-trained female cross-country mountain bike athletes. *European Journal of Applied Physiology*, *108*(1), 177–182. https://doi.org/10.1007/s00421-009-1197-0

Martin, J. C., & Spirduso, W. W. (2001). Determinants of maximal cycling power: Crank length, pedaling rate and pedal speed. *European Journal of Applied Physiology*, *84*(5), 413–418. https://doi.org/10.1007/s004210100400

McDaniel, J., Durstine, J. L., Hand, G. A., & Martin, J. C. (2002). Determinants of metabolic cost during submaximal cycling. *Journal of Applied Physiology*, *93*(3), 823–828. https://doi.org/10.1152/japplphysiol.00982.2001

Morris, D. M., & Londeree, B. R. (1997). The Effects of Bicycle Crank Arm Length on Oxygen Consumption. In *Canadian Journal of Applied Physiology* (Vol. 22, Issue 5, pp. 429–438). https://doi.org/10.1139/h97-027

Sleivert, G. G., & Rowlands, D. S. (1996). Physical and physiological factors associated with success in the triathlon. *Sports Medicine*, *22*(1), 8–18. https://doi.org/10.2165/00007256-199622010-00002

Sørensen, A., Aune, T. K., Rangul, V., & Dalen, T. (2019). The validity of functional threshold power and moderately trained cyclists. *Sports*, *7*(217), 1–7.

Sunde, A., Støren, O., Bjerkaas, M., Larsen, M. H., Hoff, J., & Helgerud, J. (2010). Maximal strength training improves cycling economy in competitive cyclists. *The Journal of Strength and Conditioning Research*, *24*(8), 2157–2165.

Swinnen, W., Kipp, S., & Kram, R. (2018). Comparison of running and cycling economy in runners, cyclists, and triathletes. *European Journal of Applied Physiology*, *118*(7), 1331–1338. https://doi.org/10.1007/s00421-018-3865-4

Too, D., & Landwer, G. E. (2000). The effect of pedal crank arm length on joint angle and power production in upright cycle ergometry. *Journal of Sports Sciences*, *18*(3), 153–161. https://doi.org/10.1080/026404100365054

Watanabe, K. (2020). Effect of seat tube angle and crank arm length on metabolic and neuromuscular responses and lower extremity joint kinematics during pedaling with a relatively lower seat height. *European Journal of Applied Physiology*, *120*(3), 697–706. https://doi.org/10.1007/s00421-020-04309-5

About the Authors

Boram Lim https://orcid.org/0000-0001-8826-7807
John A. Mercer https://orcid.org/0000-0002-6221-881X