International Journal of EXERCISE SCIENCE

Original Research

Cycling with Short Crank Lengths Improved Economy in Novices

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ABSTRACT

International Journal of Exercise Science 14(1): 1123-1137, 2021. Novice endurance athletes utilize slower movements and smaller ranges of motion compared to trained endurance athletes. Novice cyclists have been shown to follow this paradigm via the use of slower cadences but may further benefit by utilizing shorter crank lengths to affect speed of movement and range of motion. The purpose of the study was to determine the impact of shorter than traditional crank lengths on the physiological response and performance of novice cyclists exercising at 60% of VO_{2peak}. A total of 14 male novice cyclists (25.9 ± 6.9 yrs.) participated in the study. Participants completed an incremental cycle test to determine VO_{2peak}. Experimental trials consisted of 30 min cycling bouts at 60% of VO_{2peak}; one session using a traditional crank length (175 mm), the other used a short crank length (145 mm). Experimental trials were randomized. Repeated Measures ANOVAs were used to compare power output, cycling economy, RER, V_E, HR, RPE, pedal speed and cadence between crank length conditions. Power output (p = 0.002) and cycling economy (p = 0.002) were significantly higher at all time points during the short crank length condition. Pedal speed (p = 0.001) was significantly lower at all time points during the short crank length condition. Novice cyclists were able to ride with improved economy and higher power output while using short crank lengths. These improvements may be related to the slower pedal speeds, slower muscle contraction velocities and more extended hip and knee joints that a short crank length affords.

KEY WORDS: Crank arm, untrained cyclists, endurance exercise, bike fit

INTRODUCTION

Since the release of the Physical Activity Guidelines for Americans in 2008, the proportion of adults meeting combined aerobic and muscle strengthening criteria has increased from 18.2% in 2008 to 24.3% in 2017 (28). Popular modes of exercise adoption among new participants include both running and cycling. Since 2010, running has increased in popularity by roughly 60% worldwide (7). Similar to running, the number of individuals participating in cycling has increased over the past decade, and specifically due to the COVID-19 pandemic, cycling participation has increased substantially since March of 2020 (2).

Novice athletes beginning a new endurance activity, such as running or cycling, typically execute different movement patterns compared with trained endurance athletes. These differences are usually reflected by smaller ranges of motion and slower movement patterns by novices compared with trained counterparts (3, 6, 9, 11, 13, 24). Novice cyclists demonstrate a propensity to self-select slower movements than trained cyclists (6, 11, 13, 24). Novice cyclists self-select a cadence of approximately 70 rpm when using traditional crank lengths, while trained cyclists typically employ a cadence of approximately 90 rpm with traditional crank lengths (6, 11, 13, 24), which is the target cadence in the trained population to benefit performance (21, 22).

Cadence is one mechanism to affect the speed of motion in cycling. Another mechanism that is rarely used by cyclists is adjusting lower extremity range of motion to affect speed of motion (1, 27). In order to manipulate joint range of motion in cycling, equipment needs to be adjusted or completely changed. When a novice cyclist acquires a bicycle, equipment selection is largely based on body height, with little consideration for the current fitness level of the new athlete. If both experience and fitness level are considered in the bicycle fit, it may be beneficial to select equipment that would allow for the novice cyclist to employ smaller ranges of motion relative to trained cyclists when cycling at the same relative intensities. Novice cyclists can achieve these proposed smaller ranges of motion by changing crank length. Manipulating crank length will affect pedal speed for a given cadence, and thus affect metabolic cost (16). The metabolically optimal crank length for novice cyclists is unknown because crank length has almost exclusively been studied in trained cyclists. Specifically, McDaniel et al. (16) found that 99% of the variation in the metabolic cost of cycling at intensities below lactate threshold with varying crank lengths is explained by mechanical power output and pedal speed. Given that pedal speed and cadence affect cycling economy and that novice cyclists self-select slower cadences than their trained counterparts (6, 11, 13, 24), a bicycle fit that allows a novice cyclist to perform smaller ranges of motion may optimize cycling economy in this population.

Crank length selection allows cyclists the proposed change in range of motion (1, 27). Crank length has traditionally been chosen loosely based on height, typically within a small range of 165-175 mm. However, researchers have demonstrated that total body height and leg length may not be a perfect predictor of crank length as these parameters have been shown to not be well correlated with the crank length that provides the optimal economy while cycling (18). The traditional crank length prescription around 175 mm comes from power output while cycling that is not typically utilized by novices (14), including work at the highest power outputs in short duration maximal testing (27). Moreover, multivariate and bivariate cost function analyses determined that cycling at low power outputs typically used by novices with a 145 mm crank length elicited the lowest cost of cycling in the average height cyclist (10, 14). These models also determined that the lowest cost of cycling for short and tall cyclists occurred with 140 and 150 mm crank lengths, respectively (10, 14). To further support the use of short crank lengths, research in amateur triathletes demonstrated that a crank length of 145 mm was the most economical when cycling at a sub-threshold intensity used in long distance triathlon races (19). Chapman et al. (4) found that triathletes and novice cyclists exhibit similar muscle recruitment patterns that are different from trained cyclists. Therefore, novice cyclists may benefit from utilizing 145 mm crank lengths due to their similarities in muscle recruitment patterns with triathletes. Self-selection of shorter crank lengths allowing for slower movements and smaller range of motion may be related to cycling economy and sustained power output of novice cyclists as they embark on a new sport endeavor (16, 27).

Accordingly, the aim of the current investigation was to examine the effect of shorter than traditional crank length on the physiological response and performance of novice cyclists during a sustained moderate intensity cycling bout. It was hypothesized that novice cyclists would exhibit an improved cycling economy when using a short crank length compared to a traditional crank length when cycling at the same oxygen consumption.

METHODS

Participants

A total of 14 males between the ages of 19-43 volunteered to participate in the investigation. Participants completed the written informed consent process, medical history questionnaire, and a cycling history questionnaire prior to any data being collected. In order to be classified as a novice cyclist and participate in the current investigation, individuals could not have used the cycling mode for exercise training in the past; nor could individuals be currently commuting or have commuted in the past via cycling. All methods and procedures were reviewed and approved by the Institutional Review Board of Humboldt State University. This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (20). See Table 1 for demographics of participants.

Table 1. Descriptive statistics of participants represented as mean and standard deviations (n = 14).

Age	25.92 ± 6.93
VO_{2peak} (ml · kg^{-1} · min^{-1})	44.24 ± 4.84
Height (m)	1.76 ± 0.09
Weight (kg)	76.19 ± 8.51
Body Fat (%)	11.12 ± 5.56

Note: m = meters; kg = kilograms

Protocol

The current investigation was designed as a single-blind, randomized counterbalanced format. Double-blind was not attainable due to the researchers having to adjust the crank length ahead of experimental conditions. Data were obtained over the course of three testing sessions for all participants. The study was conducted in a repeated measures design, allowing each participant to serve as their own control.

Testing sessions took place in the Human Performance Laboratory on the campus of Humboldt State University. Participants reported to the laboratory on three different occasions, first for initial testing, then followed by two experimental trials. Timing of each session was replicated for each individual to help control for circadian rhythms. The first session involved the completion of the informed consent, medical history questionnaire, and the cycling history questionnaire. Mass and height were determined, and body composition was estimated via seven site skinfold procedures (Lange Skinfold Caliper, Beta Technology, Santa Cruz, CA, USA). Following body composition assessment, participants were informed of the procedures for the maximal incremental exercise test in order to determine VO_{2peak} using a metabolic system (TrueOne 2400, Parvo Medics, Sandy, UT, USA). An electronically-braked Velotron cycle ergometer (RacerMate Inc., Seattle, WA, USA) was used for the incremental test and all other testing sessions. Prior to the incremental test, a bike fit was performed in order to produce the following body angles: 30 degree knee segment angle at bottom dead center and a 45 degree torso segment angle. The handlebars were adjusted for comfort to allow for a 45 degree torso segment angle. The saddle height was adjusted to produce the same 30 degree knee segment angle at bottom dead center for both the 145 and 175 mm crank length conditions. For example, an individual requires a higher saddle height relative to the center of the crank when using the 145 mm crank length compared to a 175 mm crank length when maintaining a knee segment angle of 30 degrees at bottom dead center. Refer to Figure 1 for a representation of bike fit parameters. Angles were measured via an extendable goniometer. The adjustable cranks (M8 X-Lite, Power Cranks, Walnut Creek, CA, USA) were set to 175 mm for each individual (Figure 2). The incremental test consisted of 3 min stages, starting at 50 Watts, and increasing by 25 Watts each stage. In order to obtain a valid VO_{2peak} the following criteria was used: an RER value greater than 1.20 coupled with a heart rate value greater than 95% of age predicted max, or when the subject reached volitional exhaustion. The VO_{2peak} achieved during the incremental test was used to determine the intensity of experimental crank length trials.

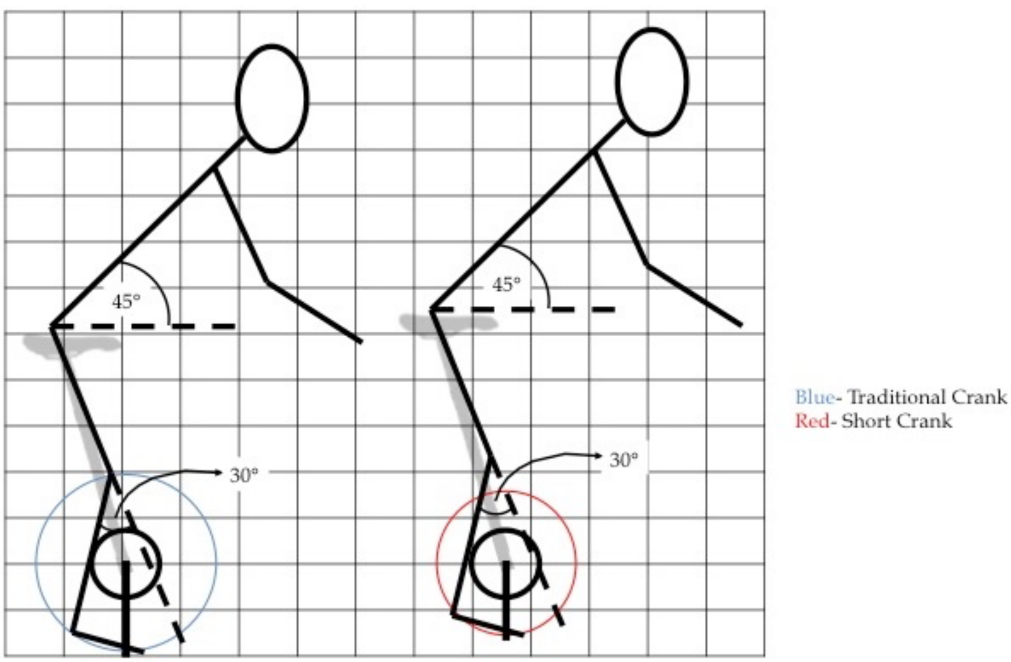

Figure 1. Standard bike fit parameters with saddle height determined based on knee segment angle of 30 degrees for both 175 mm and 145 mm crank lengths at bottom dead center.

Figure 2. PowerCranks adjustable crank set.

Prior to the experimental crank length trials, participants were instructed to refrain from strenuous exercise 48 hours prior to the sessions. Participants were also told to not consume any alcohol or caffeine within 12 hours of the sessions and to eat similar foods before each session. In order to eliminate the impact of the ordinal effect, experimental sessions were randomized. The exercise task for the experimental sessions consisted of a five min warm up at 40% of VO_{2peak}, followed by 30 min of cycling at 60% of VO_{2peak} determined from the incremental test. The first 10 min of the 30 min protocol was used to slowly ramp up the intensity to ensure that each participant was at 60% of VO_{2peak} by 10 min into the protocol. Investigators monitored oxygen consumption by keeping participants within ± 1.5 $ml \cdot kg^{-1} \cdot min^{-1}$ of 60% VO_{2peak}, and adjusted power output to keep participants within this range. Participants were instructed to cycle with a comfortable self-selected cadence. Each participant completed one 30 min session using a traditional crank length of 175 mm, while also completing another session using a short crank length of 145 mm in a randomized order. A minimum of 48 hours took place between experimental sessions for each participant. Bike fit was adjusted to maintain the same body angles during each session (Figure 1).

During both experimental crank length sessions (traditional crank length, 175 mm and short crank length, 145 mm), power output (Watts), cycling economy (Watts/absolute VO_2), RER, pulmonary ventilation (V_E), heart rate (HR), rating of perceived exertion (RPE; 0-10 scale), cadence (RPM) and pedal speed ($m \cdot s^{-1}$) were measured after 10 min at 60% of VO_{2peak}, and at every 5 min interval throughout the 30 min protocol (10, 15, 20, 25 and 30 min.). Blood lactate was analyzed after 10 min at 60% of VO_{2peak} and every 10 min interval throughout the 30 min protocol for comfort of the participant (10, 20 and 30 min). RER and V_E were recorded via the metabolic system, HR measured via chest strap (Polar H10, Polar USA, Bethpage, NY), power output measured from the Velotron cycle ergometer and blood lactate was recorded via capillary blood drawn from the fingertips of participants (Lactate Plus, Nova Biomedical, Waltham, MA, USA). Pedal speed was calculated as: pedal speed ($m \cdot s^{-1}$) = crank length (m) x RPM x 2pi/60.

Statistical Analysis

The dependent variables in the current investigation included power output (Watts), cycling economy (Watts/absolute VO_2), RER, V_E, HR, RPE, cadence, pedal speed and blood lactate. A total of eight 2 x 5 repeated measures analysis of variances (ANOVAs) were used to assess differences in power output, cycling economy, RER, VE, HR, RPE, cadence and pedal speed across experimental trials and time. The two levels of the first independent variable (crank length condition) were traditional crank length (175 mm) and short crank length (145 mm). The five levels of the second independent variable (time), are described in the previous section. An additional 2 x 3 repeated measures ANOVA was used to assess differences in blood lactate between crank length condition and time. Blood lactate was taken at 10 min, 20 min, and 30 min intervals during the experimental trials. The Mauchly's Test of Sphericity was used to evaluate if the homogeneity of variance was violated. If significance was found for the repeated measures ANOVAs, a paired samples *t*-test was use for post hoc comparisons to determine specific time points where differences existed. SPSS was used to run all statistical analyses (IBM Corp, Version 25), and an alpha level of $p < 0.05$ was used to determine significance for the statistical analyses within the current investigation. Effect size was calculated for each dependent variable across all five time points in each condition. Effect size was calculated using Cohen's *d*. A medium effect size was determined by a Cohen's *d* value between 0.50 – 0.79. A large effect size was determined by a Cohen's *d* value ≥ .80.

RESULTS

Descriptive statistics (group means and standard error of the means) for all dependent variables included in the repeated measures ANOVAs can be found in Table 2. Significant main effects for crank length condition were found for the following dependent variables: power output ($p = 0.002$), cycling economy ($p = 0.002$), pedal speed ($p = 0.001$) and cadence ($p = 0.037$).

Post hoc analyses revealed that power output was significantly greater at all time points (10 min, $p = 0.012$; 15 min, $p = 0.008$; 20 min, $p = 0.002$; 25 min, $p = 0.002$; 30 min, $p = 0.006$) in the short crank length condition compared to the traditional crank length condition (Figure 3). Post hoc analyses revealed that cycling economy was significantly greater at all time points (10 min, $p = 0.016$; 15 min, $p = 0.029$; 20 min, $p = 0.008$; 25 min, $p = 0.005$; 30 min, $p = 0.002$) in the short crank length condition compared to the traditional crank length condition (Figure 4). Post hoc analyses displayed that pedal speed was significantly lower at all time points (10 min, $p = 0.006$; 15 min, $p = 0.002$; 20 min, $p = 0.001$; 25 min, $p < 0.001$; 30 min, $p < 0.001$) in the short crank length condition compared to the traditional crank length condition (Figure 5). Finally, post hoc analyses revealed that cadence was significantly greater at two time points (25 min, $p = 0.049$; 30 min, $p = 0.011$) in the short crank length condition compared to the traditional crank length condition (Figure 6). No other significant differences existed between crank length condition ($p > 0.05$) for RER, VE, HR, RPE and blood lactate.

Table 2. Descriptive statistics of mean values and standard error of the means for dependent variables at all time points for traditional crank length and short crank length conditions.

	10 min	15 min	20 min	25 min	30 min
Power Output					
TC	133 ± 7.9	134 ± 7.9	132 ± 8.0	130 ± 8.0	129 ± 8.0
SC	137 ± 8.1*	139 ± 8.4*	139 ± 8.4*	136 ± 8.1*	134 ± 8.1*
ES	0.14	0.17	0.23	0.20	0.20
Cycling Economy					
TC	68.3 ± 1.7	65.8 ± 1.3	63.9 ± 1.5	62.6 ± 1.5	61.0 ± 1.7
SC	71.2 ± 2.0*	69.8 ± 2.2*	68.5 ± 2.0*	67.3 ± 1.8*	67.1 ± 2.2*
ES	0.40	0.59^	0.70^	0.76^	0.80#
RER					
TC	0.92 ± 0.007	0.92 ± 0.006	0.92 ± 0.007	0.92 ± 0.007	0.91 ± 0.008
SC	0.91 ± 0.011	0.92 ± 0.011	0.91 ± 0.009	0.91 ± 0.007	0.90 ± 0.009
ES	0.22	0.42	0.01	0.08	0.12
V_E					
TC	48.88 ± 2.0	52.28 ± 2.4	53.32 ± 2.6	54.00 ± 2.5	54.59 ± 2.6
SC	48.37 ± 2.1	51.41 ± 2.7	53.43 ± 2.7	53.23 ± 2.9	53.32 ± 2.9
ES	0.06	0.09	0.01	0.08	0.12
HR					
TC	133 ± 2.7	138 ± 2.5	142 ± 2.6	144 ± 2.6	144 ± 3.0
SC	132 ± 2.9	137 ± 3.0	140 ± 3.0	143 ± 2.7	144 ± 2.9
ES	0.11	0.13	0.10	0.09	0.04
RPE					
TC	3.3 ± 0.3	3.9 ± 0.3	4.6 ± 0.3	4.9 ± 0.4	5.1 ± 0.4
SC	3.4 ± 0.2	4.1 ± 0.3	4.6 ± 0.4	5.1 ± 0.4	5.4 ± 0.5
ES	0.04	0.19	0.05	0.16	0.19
Cadence					
TC	68.7 ± 2.7	70.8 ± 2.8	71.9 ± 2.5	73.7 ± 2.5	73.2 ± 2.5
SC	73.0 ± 1.8	75.0 ± 1.9	76.2 ± 2.1	77.7 ± 2.0*	78.2 ± 1.9*
ES	0.50^	0.53^	0.50^	0.47	0.61^
Pedal Speed					
TC	1.26 ± 0.05	1.20 ± 0.05	1.32 ± 0.05	1.35 ± 0.05	1.34 ± 0.05
SC	1.11 ± 0.02*	1.15 ± 0.03*	1.16 ± 0.03*	1.18 ± 0.02*	1.19 ± 0.03*
ES	1.00#	0.99#	1.08#	1.19#	1.07#
Blood Lactate					
TC	2.72 ± 0.2		2.71 ± 0.2		2.72 ± 0.3
SC	2.63 ± 0.3		2.65 ± 0.3		2.83 ± 0.3
ES	0.10		0.07		0.10

Note: Effect size data is represented for each dependent variable at all time points. Time is represented as min at 60% of VO_{2peak} for the crank length experimental trials. RER = respiratory exchange ratio; V_E = minute ventilation; HR = heart rate; RPE = rating of perceived exertion; TC = traditional crank length (175 mm); SC = short crank length (145 mm); ES = effect size (Cohen's *d*). Power output in watts. Cycling economy in watts/(liters/min); V_E in liters/min; HR in beats per minute; RPE as rating of perceived exertion 1-10 scale; Cadence in revolutions per minute; Pedal speed in meters/second. Blood lactate in mmol/L. *Indicates significant difference between crank lengths; ^Indicates medium effect size (0.50 - 0.79). #Indicates large effect size (≥ 0.80).

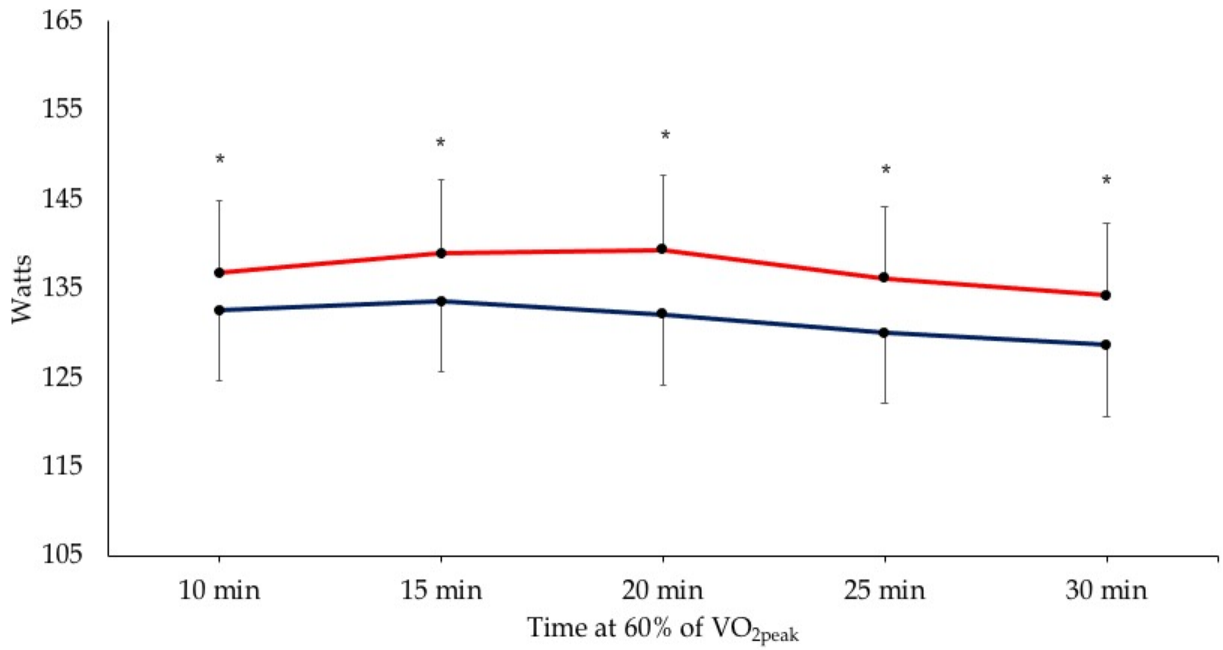

Figure 3. Difference in power output between crank length conditions when maintaining 60% of VO_{2peak}. Red line represents short crank length (145 mm) trial. Blue line represents traditional crank length (175 mm) trial. Data are represented as group means and standard error of the means. VO_{2peak} = peak oxygen uptake in $ml \cdot kg^{-1} \cdot min^{-1}$. *Indicates significant ($p < 0.05$) differences between short crank and traditional crank conditions at specific time point.

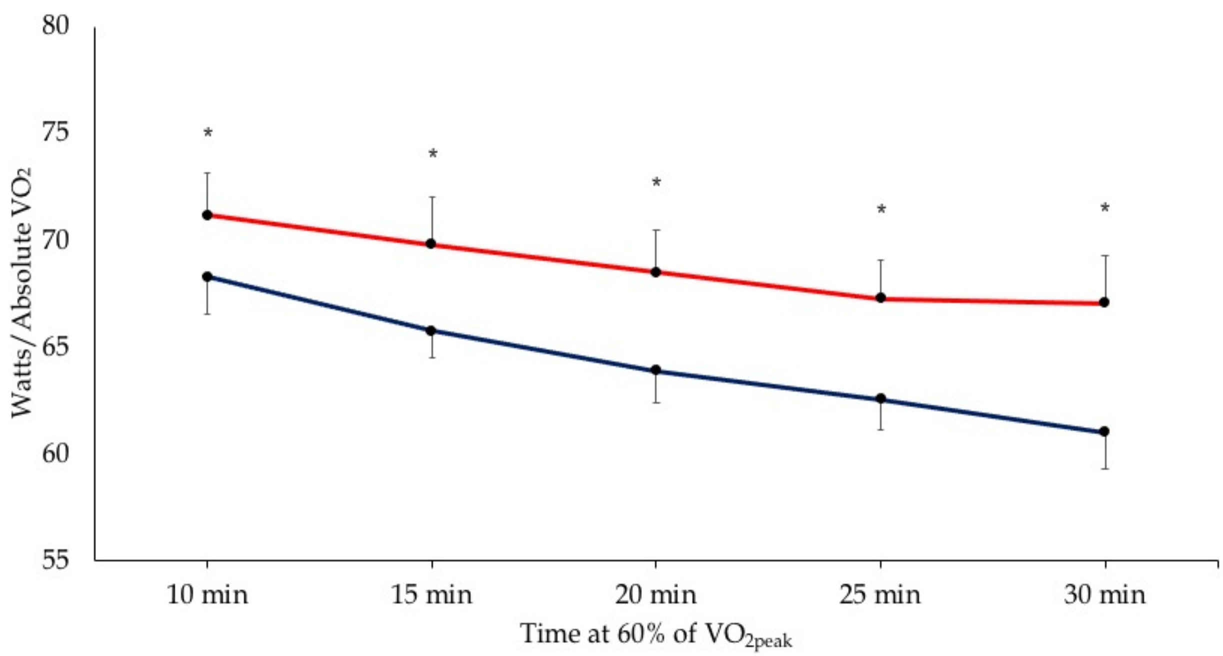

Figure 4. Difference in cycling economy between crank length conditions when maintaining 60% of VO_{2peak}. Red line represents short crank length (145 mm) trial. Blue line represents traditional crank length (175 mm) trial. Data are represented as group means and standard error of the means. VO_{2peak} = peak oxygen uptake in $ml \cdot kg^{-1} \cdot min^{-1}$. *Indicates significant ($p < 0.05$) differences between short crank and traditional crank conditions at specific time point.

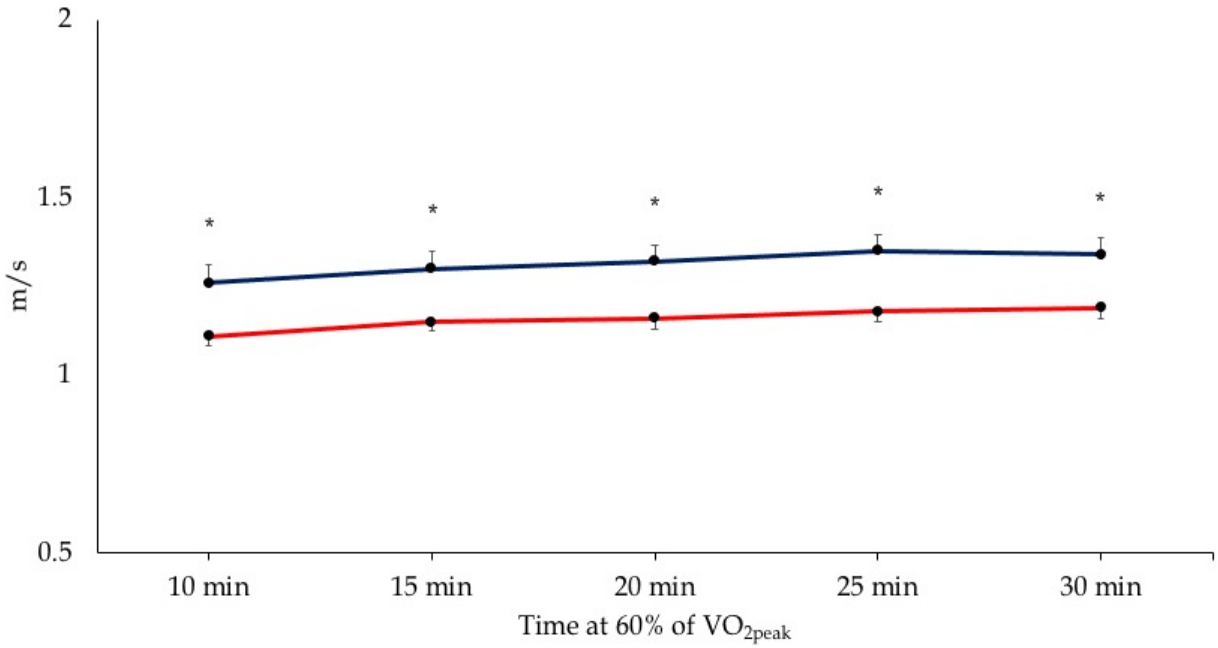

Figure 5. Difference in pedal speed between crank length conditions when maintaining 60% of VO_{2peak}. Red line represents short crank length (145 mm) trial. Blue line represents traditional crank length (175 mm) trial. Data are represented as group means and standard error of the means. VO_{2peak} = peak oxygen uptake in ml · kg^{-1} · min^{-1}. *Indicates significant (p < 0.05) differences between short crank and traditional crank conditions at specific time point.

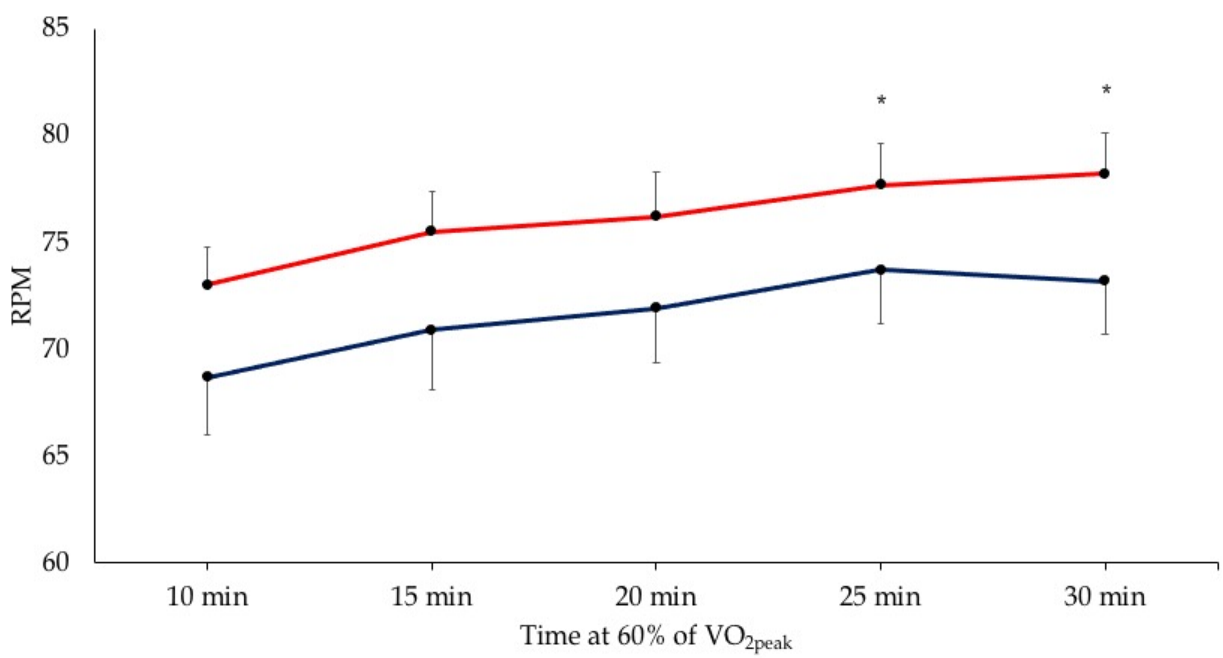

Figure 6. Difference in cadence between crank length conditions when maintaining 60% of VO_{2peak}. Red line represents short crank length (145 mm) trial. Blue line represents traditional crank length (175 mm) trial. Data are represented as group means and standard error of the means. VO_{2peak} = peak oxygen uptake in ml · kg^{-1} · min^{-1}. *Indicates significant (p < 0.05) differences between short crank and traditional crank conditions at specific time point.

Effect size for all dependent variables at each time point can be found in Table 2. A medium effect size (Cohen's d = .50 - .79) was present for cycling economy at 15 min, 20 min, and 25 min into the cycling bout, with a large effect (Cohen's d = ≥ .80) at 30 min. A medium effect size (Cohen's d = .50 - .79) was found for cadence at 10 min, 15 min, 20 min and 30 min. A large effect (Cohen's d = ≥ .80) was found at all five time points for pedal speed.

DISCUSSION

The purpose of this study was to examine the effect of short crank lengths in novice cyclists while riding at a moderate intensity. It was hypothesized that the novice cyclists would have better cycling economy via higher power output when using a 145 mm crank length compared to the traditional 175 mm crank length at the same oxygen consumption. This hypothesis was supported: novice cyclists were able to cycle with better economy and 3-5.5% greater power with shorter crank lengths at 60% of VO_{2peak} for the entire 30 min cycling bout accompanied by no difference in physiological parameters; including HR, V_E, RER, blood lactate concentration, as well as no difference in RPE. Though there was a significant difference in power output between crank length conditions, the effect size was small at all time points. Despite a small effect on power output, the short crank length produced both medium and large effects on cycling economy throughout the cycling bout.

The potential benefit of short crank lengths to novice cyclists may relate to slower movement patterns relative to those exhibited by trained cyclists. Novice cyclists differ from trained cyclists by using a lower cadence and lower power output at the same relative intensity (6, 11, 13, 24). The novice cyclists in the current investigation employed a lower cadence of around 70 rpm with the traditional crank length, as observed in previous research (6, 11, 13, 24). Individuals are most economical when utilizing self-selected movement patterns (12, 22, 26). Neptune and Hull (22) found that pedaling outside of an optimal cadence has a negative effect on endurance. Cyclists can only adjust their leg and pedal speed on a given bicycle by changing their cadence due to the constrained length of the crank. As noted in previous research (16), and supported by the current study, a cyclist may employ a higher cadence with shorter cranks, yet still have a significantly lower pedal speed than with longer traditional crank lengths. In the present study, cadence when using a 145 mm crank length would need to be over 14 rpm higher than with a 175 mm crank length in order to have equal pedal speed due to the pedal circumference difference between the crank lengths. Use of shorter crank lengths may allow a cyclist to adjust pedal speed through an additional mechanism other than cadence. That is, use of shorter crank lengths permits cyclists to affect pedal speed by moving their pedals through a smaller circumference than traditional crank lengths, therefore producing a similar, or even higher, cadence while maintaining a slower pedal speed with short crank lengths vs traditional crank lengths. McDaniel et al. (16) demonstrated pedal speed has a greater effect on the metabolic cost of cycling when compared with cadence.

Moreover, slower pedal speeds, as observed in the present study with the shorter crank length, may be associated with slower, more economical, muscle contraction velocities (17, 26). Elliot and Worthington (8) further expand on the metabolic cost of muscle shortening velocity by demonstrating that viscous damping increases internal resistance with faster muscle contractions. As such, we suggest that short crank lengths could be beneficial to the novice cyclist due to the potential they allow for slower contraction velocities and less accompanying viscous drag than longer crank lengths, which could combine to allow for more economical movement. Given that the novice participants in the current study used slower pedal speeds with short crank lengths, they may have benefited from the presumably slower muscle contractions when riding compared with traditional crank lengths. As such, the slower pedal speed and small pedal circle likely allowed the novice participants to move in their own most economical pattern. Electromyography and/or musculoskeletal modeling studies are required to confirm these proposed effects.

The improved cycling economy observed in the novice cyclists using short crank lengths for this study could also relate to the fact that novice cyclists while utilizing lower cadences and pedals speeds (6, 11, 13, 24) also recruit leg musculature in a different pattern compared to trained cyclists (4). Chapman et al. (4) demonstrated that trained cyclists employ regimented on-off periods of muscle contraction, while novice cyclists utilize more erratic muscle contractions with less muscle relaxation time during the pedal cycle. The periods of extended muscle activation are accompanied by more agonist-antagonist muscle coactivation in novice cyclists. Neptune and van den Bogert (23) add to this concept by determining that incomplete muscle relaxation could increase the metabolic cost of cycling. The combined knowledge that incomplete muscle relaxation can increase cost of motion (23) along with the finding that novice cyclists have been shown to spend more time with errant muscle contraction during cycling (4) could be a contributing factor for the novice cyclists having improved cycling economy while utilizing short crank lengths as occurred in the present investigation. When pedaling with short crank lengths, a novice cyclist could move more quickly through the section of the pedal cycle that elicits the increased errant and non-propulsive muscle firing, allowing for less wasted muscle contraction and better cycling economy.

Another factor that may have contributed to the improved cycling economy of the novice cyclists in the current investigation is range of motion at the hip and knee joints when cycling with short versus traditional crank lengths. Reported previously, use of short crank lengths elicits 5 degrees less range of motion at the hip and 7-9 degrees less range of motion at the knee when compared to cycling with traditional crank lengths (1, 27). Extrapolating this previous work to the bike fit in current study suggests that the ranges of motion at the knee would be 30-95 knee segment angle for the short crank length (27) and 30-103 knee segment angle for the traditional crank length (1). These differences are demonstrated in Figure 1 as this was fit parameter. The most flexed position is referenced in Figure 7a. Figure 7b demonstrates that the more extended leg position using short crank lengths will occur during the power stroke phase of the pedal cycle. Although joint angles were not measured during the cycling protocol in the current study, the likely smaller range of motion used with short crank lengths by the novice cyclists in this study may contribute to improved economy in multiple ways. Using a smaller range of motion during the cycling bouts with the short crank length would lead to slower joint velocities than the traditional crank length. Barratt et al. (1) reported non-significant slower joint velocities of 3 degree/second slower knee extension velocity and 3 degree/second slower hip extension velocity when utilizing short crank lengths even while cycling at a cadence of 8 rpm faster than a traditional crank length. Slower joint velocities have been strongly correlated to slower pedal speed and both measures of slower joint velocities and pedal speed are indicators of muscle contraction velocity and improved economy (15, 17, 26).

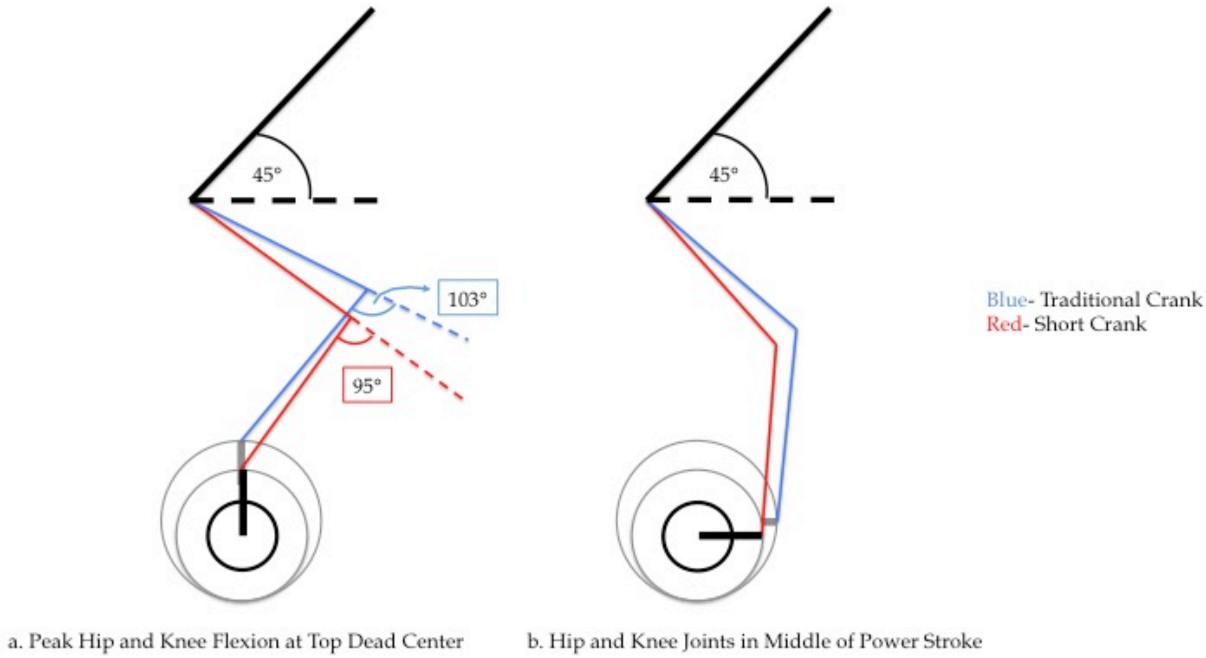

Figure 7. Reference diagrams were created as an overlay from a single subject to denote the difference leg and joint positions between crank lengths with appropriate scale for crank lengths and pedal circumferences. The joint segment angles were determined by using previous research and extrapolating the peak joint flexion angles based on the starting bike fit knee segment angle and adding the reference range of motion to the base bike fit (1, 5).

A second possible contributing factor for which shorter crank lengths and thus smaller ranges of motion improved the observed cycling economy could be related to the specific range of motion utilized with more extended hip and knee joints. A more extended leg has resulted in greater cycling economy in research examining optimal saddle height; increasing saddle height to achieve optimal knee extension of 25 degrees in trained cyclists at bottom dead center resulted in better economy than a slightly lower seat height with greater hip and knee joint flexion (25). Finally, the more extended leg by novice cyclists using the short crank length in the present study may have resulted in improved cycling economy as a result of shorter moment arms between pedal force and the hip and knee in comparison to the traditional crank length. These potential mechanisms should be validated in future studies including the collection of pedal force and kinematic data during the cycling trials.

In conclusion, our data indicate that novice cyclists can exhibit improved cycling economy when using short 145 mm crank length compared to a more traditional crank length of 175 mm when cycling at the same relative intensity, with no difference in physiological parameters. As there are more novice cyclists beginning their cycling journey, these new riders may benefit from this knowledge. The education of novice riders would require support from the bike industry and bike shops, as novice cyclists may not know that changing their crank length could benefit their riding, or that changing crank length is even an option. At this time, there are only a handful of companies that produce crank lengths of 145 mm, and no bicycle manufacturer ships a stock adult bicycle with this length of crank. Anthropometrics should be considered in crank length determination of novice cyclists, however, the traditional range utilized for prescription of crank length based on height may not be optimal. The current investigation supports novice cyclists utilizing short crank lengths for improved cycling economy, but novice cyclists do not remain beginners and untrained for long. Future research is needed to determine if novice cyclists should continue to use shorter crank lengths as their fitness and skill improve or would these now trained cyclists benefit in transitioning to traditional longer crank lengths used by trained cyclists.

ACKNOWLEDGMENTS

The authors would like to thank all individuals that assisted with the data collection process. Also, the authors would like thank Dr. Chris Fink for providing feedback on the manuscript before submission. Lastly, the authors would like to thank Dr. Allison Gruber for providing comments and feedback that improved the quality of the manuscript.

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