International Journal of
Science and Engineering Investigations vol. 8, issue 86, March 2019
Received on March 23, 2019 ISSN: 2251-8843

Optimally Positioned Elliptical Chainrings Show No Performance or Physiological Effects in 30s Sprints

A. Cole Meyers[1], Michelle L. Brown[2], Dylan R. Rose[3], Nikole A. Koellner[4]
[1]Assistant Professor, Kinesiology, Augusta University, Augusta, GA
[2,3,4]Dept. of Kinesiology, Augusta University, Augusta, GA
([1]amomeyers@augusta.edu)

***Abstract*-** Some studies have shown an increase in performance in very short duration events (e.g., a sprint) when using elliptical chainring. Computer modeling of these chainrings has shown that manufacturer-suggested installation is not optimal for increased average power output or decreased joint moments of the hip, knee, and ankle. The purpose of this study was to determine whether "optimizing" the position of elliptical chainrings would improve performance. 6 subjects performed 5, 30s Wingate tests; 3 tests with each of 5 chainring conditions. Performance was measured by peak power output (PP), mean power output (MP), and fatigue index (FI). Physiological effort was ascertained by blood lactate taken by fingerstick pre-test, post-test, and at 10, 20, and 30 minutes of passive recovery. Tests were separated by 24 hours. Two-way repeated-measures ANOVAs were performed to determine the effects of time and chainring on dependent variables. Pairwise comparison showed that the Osymetric Optimal condition had significantly lower PP values than the Circular condition, p=0.007, and Rotor condition, p=0.02. There were no other significant performance effects. There was a main effect of chainring on 20-minute recovered blood lactate levels, p=0.026. Optimally positioned chainrings show a negative trend on performance, and no consistent effect on physiological effort.

***Keywords*-** *Chainring, Cycling, Elliptical, Wingate, Performance*

I. INTRODUCTION

Elliptical chainrings are defined by the ratio of the longest diameter (major axis) to the shortest diameter (minor axis). By adjusting the major axis-to-crankarm angle, one is effectively changing the relationship between the greatest torque arm (major axis) and position of the crankarm when the leg is extending, taking advantage of the great force production capabilities of the leg when extending. Manufacturers of non-circular bicycle chainrings claim that use of their products can improve performance and decrease lactic acid production during exercise [1, 2]. However, manufacturers have an interest in positive marketing for their product, putting companies and researchers at odds regarding questions on the effectiveness of elliptical chainrings.

In a report commissioned by Rotor Bicycle Components in 2003, Tricás-Moreno et al found that use of an elliptical chainring greatly affected subjective measures of cycling. Participants noticed differences in their pedaling pattern, felt stronger, and perceived less patellar pressure sensation while using elliptical chainrings [3]. Tricás-Moreno reported no performance measures, instead saving them "for a later analysis", which never materialized [3]. Arniches [4] reported a case study in which a single athlete performed a predetermined ride every two days for six months – the first three with a traditional round chainring, and the last three with an elliptical chainring. The elliptical chainring resulted in a general increase in speed, and reduction in heart rate and time spent above anaerobic threshold for time-matched rides. Puzzlingly, the analysis makes no mention of what seems to be an obvious training effect. Studies by Sassi [5] and Montfort-l'Amaury [6] both claim to show that non-circular chainrings increase power output or reduces physiological effort while riding, but these too suffer from some fatal flaw. Sassi [5] reports significant increases in 'output' (defined as a ratio of "provided energy/consummated energy") while using non-circular chainrings. His assertion that non-circular chainrings are better than round chainrings is based on a comparison of 'output variation' ($t=-2.31$, $p<0.05$), not 'output' itself. Montfort-l'Amaury [6] reports an observed increase of 6.8W when using non-circular chainrings, but fails to include statistical analysis. Other "supporting evidence" is even flimsier: Conconi (personal communication, 1998) relates his personal experiences and claims that he and subjects in his laboratory all showed increased lactate threshold while using non-circular chainrings. These are only a few examples of 'results' which, despite their obvious shortcomings, are plastered on websites, promising cyclists great improvement for minimal work.

Peer-reviewed literature is less unanimous regarding performance effects. A review by Bini et al [7] drew no strong conclusions regarding changes in performance when cycling with elliptical chainrings. Ratel et al [8] tested thirteen cyclists using a stage-protocol VO2max test and found no significant differences in submaximal or maximal ventilation, oxygen uptake, carbon dioxide output, or heart rate between circular and Osymetric Harmonic chainrings. Dagnese's 100W stage exercise test determined there was no differences in pedaling cadence, maximal power output, or maximal heart rate between chainring types [9]. Horvais et al's [10] subjects had no significant differences in gross efficiency during submaximal 8 minute rides at 100 and 200W. Belen et al's incremental cycle-to-exhaustion test showed that eccentric chainrings lowered maximal speed at exhaustion while raising significantly raising oxygen consumption [11]; Only a white paper by Barani [12] demonstrated an improvement in power output at submaximal intensities for experienced cyclists. On the whole, the literature does not support elliptical chainrings having an appreciable effect on cycling physiology.

Two publications do qualify the seemingly overwhelming results described above. Leong [13] showed that workrate, pedaling cadence, and their interaction had no effect on crank angular velocity or ankle extension angular velocity, but did affect hip and knee extension angular velocities while riding. While no physiological variables were different between conditions, Leong's research agrees with Carpes et al [14] and may open the door to more focused examination of the interaction of kinematics and kinetics, and physiological response when using elliptical chainrings – something Kautz and Hull [15] pointed out was often overlooked in studies examining the effect of chainring shape on physiological variables. Hintzy and Horvais [16] asked ten male non-cyclists to perform incremental maximal tests with circular and non-circular chainrings. Their results showed a significant increase in maximal aerobic power when using the non-circular chainring. They suggest that conservation of energy during the early stages of the test may have affected the results. We might infer from these results that there is an experience or training factor which affects elliptical chainring effectiveness that has been previously unexamined. The authors note that while the effect is not seen in experienced cyclists, it does allow us to link cycling equipment design with physiological response [16].

Despite the general consensus that elliptical chainrings do not affect aerobic cycling performance, some studies do hold out hope that they may affect anaerobic or spring performance. O'Hara [17] found that after submaximal riding, riders performed a 1-km time trial 1.6s faster than those using circular chainrings, at a higher speed (+.7kph) and power output (+26W). Riders also displayed lower VO2 and HR at submaximal levels. While O'Hara's study used a training intervention (elliptical chainrings were tested after 6 weeks), it is important to note that the study did find significant differences between elliptical and circular chainrings after only one week, suggesting that elliptical chainrings have a real effect, and the results seen were not solely training-dependent. Similarly, Cordova et al [18] found that elliptical chainrings produced 2.5-6.5% increases in power during short (20s) sprints after an incremental test, but no change in physiological variables (VO2, HR). Hue et al [19] has also published work showing that elliptical chainrings save ~5s over 1km when tested under laboratory conditions. While an outdoor 1km test showed no significant performance differences between chainring types, later work by Hue [20] was able to correlate lower limb muscle volume with time saved, suggesting that body type may play a role in elliptical chainring effectiveness. Only Belen et al [11] and Hue et al [20] examined the effects of chainring shape on blood lactate levels while riding; during submaximal and 1km all-out exercise testing, lactate levels were similar between circular and elliptical. Despite this lack of data, one company chooses to advocate their chainring as reducing submaximal lactate/raising lactate threshold, an obvious benefit to any endurance athlete.

This study was designed to combine two factors shown in the literature: First, the proposed performance benefit connected with elliptical chainring use over short distances, as outlined above. The second, correction of a theoretical 'mis-positioning' of elliptical chainrings, as outlined by Malfait et al in 2010 [21]. Malfait and his colleagues produced a computer simulation of ten non-circular chainrings to determine the 'optimal' angle of the ellipse's major axis-to-crankarm based on two criteria: First, that it should produce "the lowest peak power load in the joint, given the same crank power development", and secondly, should show the "highest crank power efficiency, combined with lowest peak power load in the extensor joint muscles of the knee and hip, given the same joint moments" [21]. The final computer model showed that the manufacturer-recommended installation oriented the chainring major axis anywhere from 7.5 – 56.5 degrees out of phase with the crankarm. In some cases, peak knee power for the same crank power was decreased by 13.5% and crank power for the same joint moments was increased by 6.8% by correcting the position of the chainring. One important fact to point out is that while large increases or decreases may have a significant effect on cycling performance, the differences spanned Malfait's baseline numbers using a circular chainring. While crank power was increased by 6.8% from original to optimal setups for one chainring, the original position decreased crank power by 6.4% compared to circular – so the 'optimal' position only increased it 0.4% from the same point. This should not discourage research on optimal positioning of chainrings, however: Some positions demonstrated increases in crank power greater than 2.5% and decreases in joint moments greater than 7.5% compared to the circular baseline, indicating that there may be a true effect of chainring position on cycling performance.

Malfait's findings [21], in conjunction with others [17,18,19], lead us to believe that while physiological variables may not be greatly affected, elliptical chainrings may be set up in an "optimal" fashion, compared to manufacturer recommended installation, which will provide greater performance advantage than what has been previously shown in the literature. A randomised, controlled crossover study was designed to investigate changes in peak power output, mean power output, and fatigue index when using circular, manufacturer-oriented, and optimally-oriented elliptical chainrings during a 30-s Wingate test against 7.5% of participant body mass. Every participant performed 15 Wingate tests using one of five chainring types and/or orientations in a random order. Each test condition (chainring/orientation) was repeated three times to mitigate the effects of potential outliers. The Wingate test was chosen because the literature supports the use of non-circular chainrings in short-duration events (i.e. sprinting, <60s races) [17, 19]. Blood lactate before, during, and after each test was recorded to establish lactate levels and recovery curves for each of the five chainring conditions tested. It was hypothesized that, while riding with optimally-oriented elliptical chainrings, subjects would increase their peak and mean power outputs, while simultaneously decreasing their fatigue index and blood lactate levels after the test.

II. Methods

This study was designed according to the guidelines laid out by Harriss and Atkinson [22], and was approved by the Augusta University Institutional Review Board Office (IRB Protocol #799390). To participate, interested individuals had to be college aged (18-30 years) adults with a normal or overweight BMI (18.5 – 29.9). Potential participants were also required to be active at least 30 minutes, 3 times a week. Individuals were excluded if they were sedentary, smokers, pregnant, had uncontrolled hypertension or were taking medications to control hypertension, or had been diagnosed with cardiovascular or musculoskeletal disease. Potential participants completed an American Council on Exercise Health History Questionnaire and a Physical Activity Readiness Questionnaire. Their height, weight, and blood pressure were measured. Those who had no risk factors identified by the ACE HHQ or PAR-Q, and passed the inclusion/exclusion criteria outlined above were walked through the informed consent document by the PI and enrolled in the study.

Each participant was given the option to combine their screening visit and first test. Otherwise, they were instructed to report to the laboratory at the end of an 8 hour fast, having had 8 hours of rest, 8 hours of no caffeine consumption, and having drunk 8fl oz of water within 60min of exercise onset. All participants were allowed extra time their first session to familiarise themselves with the bicycle ergometer (Velotron Pro, Racermate, Seattle, WA) and finger-stick protocols. They were fitted to the exercise bicycle by placing their heel on the pedal and adjusting the seat height to the level which allows full knee extension at the bottom of the pedal stroke. This value was recorded and used for each subsequent trial.

Each trial was preceded by a finger-stick to measure pre-exercise blood lactate levels. Every participant then performed a 5 minute warmup on the bicycle ergometer at 100 watts and a comfortable, self-selected cadence. After the warmup, the resistance was removed and subjects had a 5 second phase where they were instructed to pedal as fast as they could. After 5 seconds, the ergometer applied a resistance to the flywheel equivalent to 7.5% of the participant's body mass. All participants were verbally encouraged to pedal as fast and as hard as they could for the full 30 second test. Immediately afterwards, a second finger-stick was taken to ascertain blood lactate, and participants were allowed to get off the ergometer. They were instructed to sit quietly for the following 30 minutes, and the research team took finger-sticks for blood lactate at 10, 20, and 30 minutes of recovery. Participants performed 1 Wingate per visit, and test sessions were separated by a minimum of 24 hours.

Each Wingate test was performed with one of five chainring conditions. "Circular" was the baseline test condition, and used the stock circular chainring for the ergometer. "Rotor" and "Osymetric" used two popular, widely marketed elliptical chainrings in their manufacturer-recommended configurations. In this orientation, the major axis of the Rotor elliptical shape lay 74 degrees clockwise from the crankarm when the latter was positioned at the top dead center (TDC) of the pedal stroke. The major axis of the Osymetric chainring is 78 degrees clockwise to the crankarm in the same position. Malfait [21] computes that the optimal position of the Rotor chainring places the major axis 107 degrees from the crankarm. The chainring has 35 bolt holes, splitting it into 10.28 degree increments. To make up the 33 degree difference, the chainring was rotated three bolt holes clockwise with respect to the crankarm. This achieved a major axis-crankarm angle of 30.74 degrees, the closest we could approximate Malfait's optimal position. To position the Osymetric chainring in Malfait's optimal position, a custom inner chainring was created [Fig. 1]. For the sake of symmetry and strength, it was drilled with 10 bolt holes equiangular around the circumference. By rotating the inner chainring one bolt hole (36 degrees) clockwise, we were able to safely emulate Malfait's optimal position for the Osymetric condition (39 degrees).

Statistical analysis was performed using SPSS for Windows Version 20.0 (IBM Corp., Armonk, NY). Demographics are reported as means + standard deviations. Repeated-measures two-way ANOVAs were run to determine the effect of time and chainring condition on peak power output (PP), mean power output (MP), fatigue index (FI: [(PP-Min P)/PP]), and blood lactate levels. In the case that any ANOVA reached significance, post-hoc testing was performed by averaging results across time or chainring and performing a simple one-way ANOVA to determine which group caused main effect significance using Tukey's Least Significant Difference.

Figure 1. Custom inner chainring affixed to the rear of the Osymetric chainring. Bolt holes are spaced 36° apart.

III. Results

13 individuals expressed interest in participating in this study. After screening, all were qualified and consented. Six participants completed all 15 Wingate tests and were included in analysis. There were three males (24.3years [20-28], 180.3±5.48cm; 73±14.2kg) and three females (22years [20-23], 165.1±3.59cm, 63.6±6.69kg).

Repeated-measures two-way ANOVA examining the effects of trial and chainring on dependent variables were performed. There was no main effect of trial and no interaction effect of trial*chainring on any power related variables. There was a main effect of chainring on peak power output (PP), $F(4,20)=4.302$, $p=0.011$. To ascertain which chainring caused significance, post-hoc testing using Tukey's LSD was performed. The "Osymetric Optimal" condition (647W) showed significantly lower PP values than both "Circular" (815W, $p=0.007$), and "Rotor" conditions (770W, $p=0.02$) (Fig. 2). There was also a trend towards a significantly lower average peak value between "Osymetric Optimal" and "Rotor Optimal", $p=0.07$. There was a main effect of chainring on mean power output (MP), $F(4,20)=3.956$, $p=0.016$. Pairwise comparisons showed that "Osymetric Optimal" condition (454W) had significantly lower mean power output than both "Circular" (551W, $p=0.031$), and "Rotor" conditions (495W, $p=0.048$) (Fig. 3). There was no main effect of chainring on fatigue index.

Five repeated measures 2-way ANOVAs were performed to determine if there were any effects of trial and chainring on blood lactate levels pre-test, post-test, and at ten, twenty, and thirty minutes of passive recovery. Analysis showed that there were no main or interaction effects on blood lactate levels pre- or post-test, and at ten and thirty minutes of recovery. There was a main effect of chainring on blood lactate levels at twenty minutes of recovery, $F(4,20)=3.489$, $p=0.026$ (Fig 4). Pairwise comparisons showed that the "Rotor Optimal" position reduced blood lactate compared to the "Circular" (Mean Diff=-1.356; SE=0.696, $p=0.04$) and "Rotor" conditions (Mean Diff=-2.367, SE=.311, $p=0.001$).

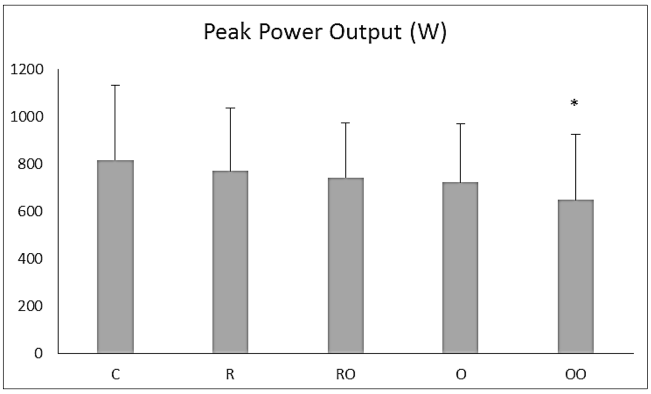

Figure 2. Peak power output differences between chainring conditions. C=Circular, 815±314W: R=Rotor, 769±264W: RO=Rotor Optimal, 742±229W: O=Osymetric, 721±246W: OO=Osymetric Optimal, 647±278W. *=significantly lower than C, R

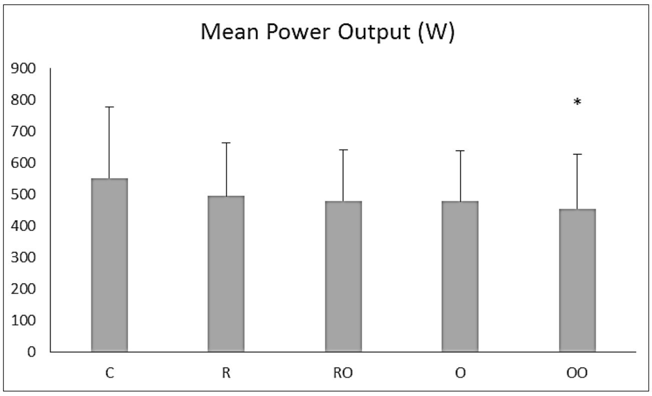

Figure 3. Mean power output differences between chainring conditions. C=Circular, 550±225W: R=Rotor, 494±169W: RO=Rotor Optimal, 479±161W: O=Osymetric, 477±162W: OO=Osymetric Optimal, 454±172W. *=significantly lower than C, R

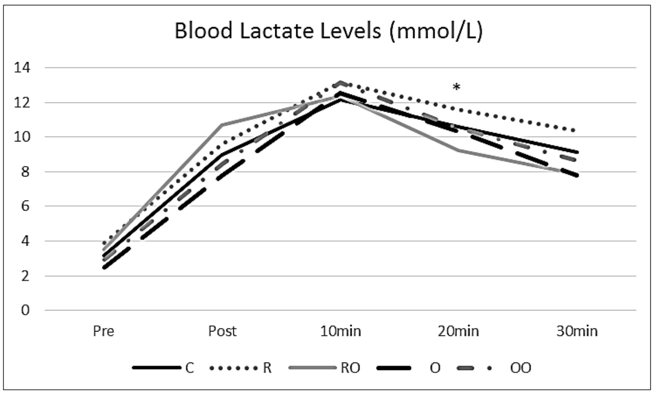

Figure 4. Blood lactate differences between chainrings at protocol timepoints. *=Rotor Optimal significantly lower than C (-1.3mmol/L, p=0.04), R (-2.3mmol/L, p=0.001)

IV. Discussion

It was hypothesised that elliptical chainrings would increase peak and mean power while decreasing fatigue index and blood lactate levels compared to circular chainrings during a 30s Wingate test. Optimally positioning the elliptical chainrings was suggested to further enhance this effect, in accordance with research by O'Hara [17] and Malfait et al [21]. None of these effects were seen; in this study, optimally positioned elliptical chainrings tended to further decrease performance compared to manufacturer-recommended setups and to circular chainrings.

This finding agrees with Leong [13], who observed that increasing chainring ovality was associated with decreasing power outputs at high pedaling rates. It is important to note that in this protocol, pedaling rate was not controlled. Many studies, typically those looking at physiological responses, have controlled pedaling rate in order to standardize test conditions as much as possible. The nature of the Wingate test does not allow such control. Research using short maximal power tests has not been concerned with the interaction of pedaling cadence, pedaling mechanics, and the effects of elliptical chainrings; this may be an important focus area for future research.

Few studies examine the effects of elliptical chainrings on blood lactate during exercise. A minor adjustment such as chainring shape should not be expected to have a major effect on a physiological response such as blood lactate concentrations, especially for bouts of maximal power output. While we did have one significant finding – that the "Rotor Optimal" condition reduced 20-minute recovery lactate compared to "Circular" and "Rotor" conditions – this should not be taken as a novel finding, since the changes are very small (1.3-2.3mmol/L) and not part of a larger trend in the data. Our findings agree with other research [11,18,20] examining lactate levels, or ventilatory threshold [19] which find no significant changes dependent on chainring shape.

Because of the large time and difficult exercise commitment, the sample size in this study was less than ideal. It was decided not to limit the study to experienced cyclists due to the unavailability of a large subject pool; additionally, the Wingate test is non-cyclist-specific, and is used as a general test of lower body and total anaerobic power across a wide range of sports. In light of Hintzy and Horvais' [16] research showing significant elliptical chainring effects in non-cyclist subjects, it was determined that the use of inexperienced participants might allow us to observe larger effects than previously seen with experienced cyclists. While our results agree with them, others [23] demonstrated marked improvements in sprint distance (but not power output) in elite bicycle motocross (BMX) racers using elliptical chainrings.

Another possible limitation, hinted to above, is inexperienced cyclists may exhibit inefficient pedaling mechanics which could exaggerate or mask the effects of elliptical chainrings. While non-cyclists tend to pedal "squares" – pushing hard on the downstroke and doing little to no work the rest of the pedal cycle – cyclists are often taught to pedal "circles", pulling the pedal up over top dead center of the pedal stroke and pushing it all the way through bottom dead center to help the other leg take over. Anecdotally, recent Tour de France winner Chris Froome (who uses elliptical chainrings) happens to pedal "squares" (Meyers, personal correspondence, 2016). Bradley Wiggins, another former Tour winner, made a very public switch back to circular chainrings after being disappointed in the performance of elliptical models. The possible existence of a training or experience effect on the effectiveness of elliptical chainrings has not been examined – however, previous research and real-world use of elliptical chainrings suggest there is some factor that has not yet been quantified, further agreeing with Leong [13] and Kautz and Hull [15]. Our current understanding of how pedaling mechanics interact with elliptical chainrings limits the generalizability of this study to experienced cyclists.

One more publication on performance effects of elliptical chainrings is not going to sway the market – these tools will still be manufactured, advertised, sold, and used. It is therefore the responsibility of researchers to continue to critically examine the effects of elliptical chainrings on the physiology, mechanics, and performance of cyclists. The research outlined in this manuscript hints at a relationship between application, rider experience, and chainring shape that has not been elucidated. Leong [13] suggests that future research should be performed on electromyographical activation of leg muscles while pedaling, possibly while using non-commercial chainrings. Malfait et al [21] agrees – in their simulation, the authors note that while the 'Osymetric Optimal' shows large improvement, the "academic" (e.g., not commercially available) 'Hull' oval [24] exhibited the greatest improvement in performance. However, the logistics of installing the 'Hull' oval on a bicycle make it near-unusable in regards to front derailleur shifting mechanics. It is the author's opinion that future research should combine the above factors to answer questions revolving around rider physiology, mechanics, and performance. Additionally, it is important that, since there are conflicting publications, future research should attempt to refine and replicate previous studies, in order to shift the literature towards more of a consensus on the subject of elliptical chainring use.

V. Conclusions

Elliptical chainrings, although marketed as a tool to improve performance on the bicycle, often fail to meet expectations when subjected to laboratory-based testing. This study showed that in recreationally-active college students, elliptical chainrings benefited neither performance nor blood lactate production during 30s Wingate tests. Future research should examine if there is an interaction between pedaling mechanics or muscle activation patterns and performance benefits of using elliptical chainrings.

References

[1] Osymetric. (2017). Benefits. Online. http://shop.osymetricusa.com/Benefits_ep_41.html

[2] Rotor Bicycle Components. (2017). Why oval chainrings? Online. http://rotorbike.com/why-q/

[3] Rotor Bicycle Components. (2003). Rotor, generator of health. Zaragoza, ESP: Tricás-Moreno, J. M., Cózar-Bartos, J. M., Caudevilla-Polo, S., Hidalgo-Garcia, C., & Herrero-Gallego, P.

[4] Senkirol. (2003). Rotor study. Bilbao, Esp: Arniches, J. B.

[5] Institut des Techniques d'Optimalisation des Pratiques Sportives. (2003). Untitled (Report on non circular chainrings). Menton, FR: Sassi, M., & Tallo, J-L.

[6] Osymetric. (2003). Comparative research on circular and non circular chain wheel. Montfort-l'Amaury, FR.

[7] Bini, R. R., & Dagnese, F. (2012). Noncircular chainrings and pedal to crank interface in cycling: a literature review. Brazilian Journal of Kinathropometry and Human Performance, 14(4), 470-482.

[8] Ratel, S., Duché, P., Hautier, C. A., Williams, C. A., & Bedu, M. (2004). Physiological responses during cycling with noncircular "Harmonic" and circular chainrings. European Journal of Applied Physiology, 91, 100-104.

[9] Dagnese, F., Carpes, F. P., Martins, E. D., Stefanyshyn, D., & Mota, C. B. (2011). Effects of a noncircular chainring system on muscle activation during cycling. Journal of Electromyography and Kinesiology, 21, 13-17.

[10] Horvais, N., Samozino, P., Zameziati, K., Hautier, C., & Hintzy, F. (2007). Effects of a non circular chainring on muscular, mechanical and physiological parameters during cycle ergometer tests. Isokinetics and Exercise Science, 15, 271-279.

[11] Belen, L., Habrard, M., Micallef, J. P., & Le Gallais, D. (2007). The performance and efficiency of cycling with a carbon fiber eccentric chainring during incremental exercise. Journal of Sports Medicine and Physical Fitness, 47, 40-45.

[12] Barani, D. (1993). Aerobic metabolism evolution comparative study during triangular effort test on bicycle equipped with a circular or a non circular chain wheel. Recherche & Developpement: Experimentation Harmonic.

[13] Leong, C. H. (2014). The influence of noncircular chainrings on maximal and submaximal cycling performance. (Unpublished doctoral dissertation). University of Utah, Salt Lake City, UT, USA.

[14] Carpes, F. P, Dagnese, F., Mota, C. B., & Stefanyshyn, D. J. (2009). Cycling with noncircular chainring system changes the three-dimensional kinematics of the lower limbs. Sports Biomechanics, 8(4), 275-283.

[15] Kautz, S. A., & Hull, M. L. (1995). Dynamic optimization analysis for equipment setup problems in endurance cycling. Journal of Biomechanics, 28(11), 1391-1401.

[16] Hintzy, F., & Horvais, N. (2015). Non-circular chainring improves aerobic cycling performance in non-cyclists. European journal of sport science, 16(4), 427-432.

[17] O'Hara, C. R., Clark, R. D., Hagobian, T., & McGaughey, K. (2012). Effects of chainring type (circular vs. Rotor Q-Ring) on 1km time trial performance over six weeks in competitive cyclists and triathletes. International Journal of Sports Science and Engineering, 6(1), 25-40.

[18] Cordova, A., Latasa, I., Seco, J., Villa, G., & Rodriguez-Falces, J. (2014). Physiological responses during cycling with oval chainrings (Q-Ring) and circular chainrings. Journal of Sports Science and Medicine, 13, 410-416.

[19] Hue, O., Galy, O., Hertogh, C., Casties, J-F., & Prefaut, C. (2001). Enhancing cycling performance using an eccentric chainring. Medicine & Science in Sports & Exercise, 33(6), 1006-1010.

[20] Hue, O., Chamari, K., Damiani, M., Blonc, S., & Hertogh, C. (2007). The use of an eccentric chainring during an outdoor 1km all-out cycling test. Journal of Science and Medicine in Sport, 10, 180-186.

[21] Malfait, L., & Storme, G. (2010). Comparative biomechanical study of circular and non-circular chainrings for endurance cycling at constant speed (2nd release). Self-published.

[22] Harriss, D. J., & Atkinson, G. (2011). Update–ethical standards in sport and exercise science research. International Journal of Sports Medicine, 32(11), 819-821.

[23] Hull, M. L., Williams, M., Williams, K., & Kautz, S. (1992). Physiological response to cycling with both circular and noncircular chainrings. Medicine and Science in Sports and Exercise, 24(10), 1114-1122.

[24] Mateo-March, M., Fernandez-Pena, E., Blasco-Lafarga, C., Morente-Sanchez, J., & Zabala, M. (2014). Does a non-circular chainring improve performance in the bicycle motocross cycling start sprint? Journal of Sports Science and Medicine, 13, 97-104.

A. Cole Meyers is an Assistant Professor of Kinesiology and Health Sciences at Augusta University in Augusta, GA. He received his doctor of philosophy degree from the University of Miami (Coral Gables, FL) in exercise physiology with a focus on sports biomechanics.

How to Cite this Article:

Cole Meyers, A., Brown, M. L., Rose, D. R., & Koellner, N. A. (2019). Optimally Positioned Elliptical Chainrings Show No Performance or Physiological Effects in 30s Sprints. International Journal of Science and Engineering Investigations (IJSEI), 8(86), 131-136. http://www.ijsei.com/papers/ijsei-88619-19.pdf