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Positioning of Elliptical Chainrings During Wingate Testing; A Repeated Measures Case Study

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Introduction

Manufacturers of non-circular bicycle chainrings claim that use of their products can increase power output during exercise. These chainrings are generally defined as the ellipse shaped by a large diameter (major axis) and small 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 at that point.

A number of industry-sponsored “white papers” claiming increased performance have been released (Osymetric, n.d.; Barani et al, 1993). These results are trumpeted, promising great improvement for minimal work. Peer-reviewed literature is less than convinced; Bini et al (2012) found no chainring that provided consistent improvement in VO2 or HR. This result agrees with previous research on chainring shape and physiological response (Kautz and Hull, 1995; Leong, 2014; Hue et al, 2007; Ratel et al, 1998). Some studies posit that elliptical chainrings may provide mechanical benefits to a rider. Bini mentions a Spanish-language article which found subjects using elliptical chainrings for Wingate testing had 8% increases in average power and 9% increases in peak power output. O’Hara (2012) 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). Similarly, Cordova et al (2014) found that elliptical chainrings produced 2.5-6.5% increases in power during short (20s) sprints after an incremental test.

This study aims to build on previous literature while incorporating a novel finding from the field of computer science. A thesis by Malfait (2010) examined the relationship between the major axis of the chainring, and the crankarm: His findings showed most manufacturer setups were 7.5 – 66.5° out of phase. This finding, in conjunction with O'Hara and Cordova, lead us to believe that elliptical chainrings may be set up in an "optimal" fashion, compared to manufacturer recommended installation, which will provide greater mechanical advantage during Wingate testing than what has been previously shown.

Methods

One subject (male, 60.5kg, 175cm, BMI = 19.8) participated in this case study. He completed 15, 30-second Wingate tests against 7.5% of his body weight (4.54kg). All tests were performed on an electromagnetically braked cycle ergometer (Velotron Pro; Racermate, Seattle, WA). Wingate order was randomized and each chainring condition (Circular "C", Rotor Q-Ring "R", Osymetric Rings "O", Rotor Optimal "RO", Osymetric Optimal "OO") was repeated three times. Normal position for *R* was according to manufacturer-recommended setup at the bolt hole marked "···". *RO* was achieved by rotating the chainring clockwise 3 bolt holes (~31°; Malfait recommendation, 33°). *O* is preset by the chainring having only 5 bolt holes. An adapter ring was manufactured to move the major axis to the desired position. For the sake of symmetry and structural integrity, holes were evenly spaced, so *OO* is a 36° clockwise rotation instead of Malfait's recommended 39°. Peak power, mean power, and fatigue index (watts/s) were collected.

Results

Data was analyzed using a 1-way repeated measures ANOVA using Peak Power, Mean Power, and Fatigue Index as the independent variables. Mean power during the Wingate test was not significantly different between chainring conditions, $F(4,14)=1.89$, $p=.2$. Peak power trended towards significance, $F(4,14)=3.82$, $p=.0505$. Fatigue index was significant, $F(4,14)=12.04$, $p=.0018$. Post-hoc testing using Tukey's HSD showed that fatigue index using the *O* chainring condition was significantly higher than *C* ($p<.01$), *RO* ($p<.01$), and *OO* ($p<.01$). The *R* chainring condition produced significantly higher fatigue index than *C* ($p<.05$) and *OO* ($p<.05$).

Conclusions

Although manufacturers have an interest in selling their products, peer-review research is hesitant to support their claims. Our current subject showed no major differences in performance, even using an exercise type thought to maximize the benefits of elliptical chainrings (sprinting).

It is interesting to note that while it has not yet reached significance, the peak power of *O* condition is a good deal higher than any other. This may be the cause of significance in the fatigue index (where *O* was higher than *C, RO,* and *OO*). Fatigue Index is given as $FI = \frac{Peak\ W - Min\ W}{t}$. The increase in peak power, especially with a drop in minimum power at the end of the test, may have been enough to cause significance. We cannot yet say that *O* (or any chainring) is significantly better than any other chainring, especially given the non-significance of mean power output differences between conditions and the current case study design.

These conclusions should be interpreted in the context of n=1. Data collection is ongoing in other subjects, and may affect significance of results presented here.

References

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