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Research article

Effect of the Rotor crank system on cycling performance

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Abstract

The aim of this study was to evaluate the impact of a novel crank system on laboratory time-trial cycling performance. The Rotor system makes each pedal independent from the other so that the cranks are no longer fixed at 180°. Twelve male competitive but non-elite cyclists (mean ± s: 35 ± 7 yr, W_{max} = 363 ± 38 W, VO_{2peak} = 4.5 ± 0.3 $L·min^{-1}$) completed 6-weeks of their normal training using either a conventional (CON) or the novel Rotor (ROT) pedal system. All participants then completed two 40.23-km time-trials on an air-braked ergometer, one using CON and one using ROT. Mean performance speeds were not different between trials (CON = 41.7 $km·h^{-1}$ vs. ROT = 41.6 $km·h^{-1}$, $P > 0.05$). Indeed, the pedal system used during the time-trials had no impact on any of the measured variables (power output, cadence, heart rate, VO_2, RER, gross efficiency). Furthermore, the ANOVA identified no significant interaction effect between main effects (Time-trial crank system*Training crank system, $P > 0.05$). To the authors' knowledge, this is the first study to examine the effects of the Rotor system on endurance performance rather than endurance capacity. These results suggest that the Rotor system has no measurable impact on time-trial performance. However, further studies should examine the importance of the Rotor 'regulation point' and the suggestion that the Rotor system has acute ergogenic effects if used infrequently.

Key words: Gross efficiency, cycling performance, bicycle equipment.

Introduction

Power output, the product of torque and pedal velocity, is a key determinant of cycling performance (Coyle, 1995). Torque is determined by the effective force applied perpendicular to the crank arm and by crank arm length (Bertucci et al., 2005b). The maintenance of a constant effective force would optimise torque, and hence, power production (Bertucci et al., 2005b). However, anatomical and gravitational constraints mean that torque is actually produced in a nearly sinusoidal manner with minimal torque being produced at the top and bottom dead centre points of the crank cycle (Faria, 1992). Any optimisation of this crank cycle would necessarily lead to higher net torque and, therefore, power output (assuming an equivalent cadence).

Increasing crank arm length during the downstroke of the crank cycle has been shown to produce the highest peak torque (Faria, 1992). Such an effect can be achieved with the use of non-circular chainrings. Whilst their use has been approved by the Union Cycliste Internationale (UCI), few studies have actually observed improvements when using such systems (Cullen et al., 1992; Hue et al., 2001; Hue et al., 2008; Hull et al., 1992; Ratel et al., 2004). An alternative method of increasing power output is provided by the Rotor crank. This system makes each crank independent from the other such that they are no longer fixed at 180º (Santalla et al., 2002). This configuration allows the angle between the cranks to vary, resulting in the manufacturers' claim that the Rotor system eliminates the dead points where torque production is minimal. In theory, this should allow cyclists to produce propulsive force for a greater fraction of the crank cycle.

Santalla et al. (2002) investigated the effect of the Rotor system on several conventional predictors of cycling performance in a group of healthy non-cyclists. The only variable that was shown to be significantly different between groups was delta efficiency. Unfortunately, Santalla et al. (2002) calculated efficiency from data collected during 3-minute work stages. These results are questionable given that carbon dioxide uptake (VCO_2) may take longer than 3 minutes to stabilise. This is important as the calculated energy equivalent for a given oxygen uptake (VO_2) depends upon the equivalence of respiratory exchange ratio (RER) and muscle respiratory quotient (RQ). Thus, VCO_2 stability prior to gas sampling must be considered in the measurement of efficiency.

More recently, Lucia et al. (2004) assessed the effect of the Rotor system on a group of well-trained cyclists. Also using 3-minute work stages, these authors found no differences in a number of laboratory measures between the conventional and Rotor crank systems. Lucia et al. (2004) suggested that the advantage provided by the Rotor system, i.e. improved contralateral cooperation of the legs, is minimised in trained cyclists who have already learned the appropriate technique.

Whilst the Rotor system would appear not to affect common predictors of cycling performance such as VO_{2max} and lactate threshold, there is some suggestion that it may improve cycling efficiency. Cycling efficiency is a key determinant of endurance cycling performance (Coast et al., 1986; Coyle, 1995; Coyle, 1999; Horowitz et al., 1994; Moseley and Jeukendrup, 2001; Olds et al., 1995). However, whilst the impact of the Rotor system on endurance 'capacity' has been investigated (Lucia et al., 2004; Santalla et al., 2002), no study has yet examined the impact of the Rotor system on endurance 'performance'. We hypothesise that laboratory time-trial cycling performance will improve when using Rotor cranks and that this improvement will be enhanced by a period of habitual

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training using the Rotor system prior to testing.

Methods

Participants

Twelve male cyclists were recruited from local cycling clubs to participate in this investigation (participant characteristics presented in Table 1). All cyclists had previous experience of laboratory testing and competitive road time-trials. This study was approved by the Faculty of Social Sciences Ethics Committee at The University of Winchester. Prior to participation in the investigation, cyclists were fully informed of the nature and risks of the study, before providing written consent.

Table 1. Participants' physical characteristics. Data are means (±standard deviation).

N	Age (yrs)	Body mass (kg)	Stature (m)	VO_{2peak} ($L·min^{-1}$)	W_{max} (W)
12	34.6 (7.1)	75.9 (7.8)	1.77 (.07)	4.5 (.3)	363 (38)

The methods used to calculate sample size are outlined by Baguley (2004) and used the methods of Cohen (1988) and GPower software (Erdfelder et al., 1996):

$$N \text{ per group} = 2(\delta/d)^2$$

where d was the detected effect size, and power was set at 0.8.

The most appropriate selection of the likely change has attracted some debate in the literature with some authors selecting a meaningful change/difference in the parameter (Petersen et al., 2004) and others using the smallest worthwhile change of 0.2 of the between participant standard deviation (Cohen, 1988; Hopkins, 2000). For the current study, the work of Santalla et al. (2002) was consulted. The mean difference in efficiency observed between Rotor and conventional cranks was 3.3% with a standard deviation of 1.5%. The effect statistic was calculated as 3.3/1.5 = 2.2. Using GPower, the value for δ (the value for non centrality) was calculated to be 4.4. The calculated sample size was therefore at least 4 participants in each group. Two additional participants were included to minimise the impact of participant dropout.

Testing schedule

Each participant completed three experimental sessions, i) to determine participant characteristics and ii) and iii) to complete a 40.23-km cycling time-trial in the laboratory in each of two conditions. The time-trials, separated by no more than 10 days, were completed according to a randomly assigned counterbalanced, cross-over design in the northern hemisphere during the months of April, May and June.

Preliminary testing

On arrival at the laboratory, an anthropometric assessment of each cyclist was performed. Stature was measured to the nearest millimetre (Harpenden Stadiometer, Holtain Ltd, UK) and body mass to within ± 50 g (Seca 700, Seca Ltd., UK).

Participants then completed a progressive, incremental exercise test to exhaustion using their own bicycle mounted on a Kingcycle air-braked cycle ergometer (Kingcycle Ltd., High Wycombe, Buckinghamshire, UK) as described previously (Nevill et al., 2005). Participants completed a warm-up at a self-selected intensity for 10 min. Immediately following this, the maximal test was initiated at a workload of 150-200W. Thereafter, workload increased at a ramp rate of 25 $W·min^{-1}$. The test was terminated when the cyclist could no longer maintain the specified workload. Power (W) and cadence ($rev·min^{-1}$) were measured and averaged over 1.26-s intervals using a PowerTap powermeter (Saris PowerTap SL, Madison, WI). The accuracy and reproducibility of the PowerTap system have been demonstrated previously (Bertucci et al., 2005a; Gardner et al., 2004; Paton and Hopkins, 2006). Maximal aerobic power (W_{max}) was recorded as the highest mean power output over a 60-s period.

For the duration of the test, respiratory gases were recorded on a breath-by-breath basis using a Cosmed Quark b2 gas analysis system (Cosmed, Italy). The Cosmed system was calibrated prior to use according to the manufacturers guidelines, using a calibration gas of known composition and a 3-litre syringe (SensorMedics, Yorba Linda, California, USA). The Cosmed has been shown to be both valid and reliable (Norris and Smith, 1999). Maximal oxygen consumption (VO_{2peak}) was identified as a plateau in VO_2, defined as an increase of less than 1.5 $ml·kg^{-1}·min^{-1}$, and/or as a respiratory exchange ratio >1.10 (Doherty et al., 2003). VO_{2peak} was recorded as the highest mean oxygen consumption over a 60-s period.

The Rotor cranks system

Rotor cranks were fitted to the bicycles of the 6 participants randomly assigned to the ROT group. Crank length and chainring size for ROT was the same as that used with the conventional crank (CON) system by each individual participant. The Rotor system is designed with several 'regulation points', each point providing a slightly different offset between the cranks. For a full explanation of the regulation point see Rodriguez-Marroyo et al. (2009). In the present study, to avoid variation between participants the regulation point was set at the neutral (#3) position in all cases. All participants then completed 6 weeks of their normal training prior to the experimental time-trials, 6 riders being habitual CON users and 6 riders being habitual ROT users. Physical characteristics were not different between groups ($P > 0.05$).

Experimental trials

Laboratory time-trials

All participants completed two 40.23-km time-trials on the Kingcycle ergometer. Carried out in a randomised counterbalanced order, participants completed the time-trial under two conditions, i) using conventional bicycle cranks (CON) and ii) using the Rotor crank system (ROT). Cyclists were instructed to adopt the same tucked position as used when completing a 40.23-km road time-trial. Pre-test calibration of the Kingcycle was carried out with the participant in the position to be adopted during the time-trial. Immediately prior to the commencement of the time-trial, participants completed a warm-up consisting of two consecutive 8-minute stages at 200 and 225 W. On completion of the warm-up, participants were asked to cover the 40.23-km distance as quickly as possible. During these trials the only information available to the cyclist was the percentage of race distance remaining as indicated by the Kingcycle software.

Power output (W) and respiratory gases were measured for the duration of the trial as described above. These data were used to calculate gross efficiency during the final stage of the warm-up and during the time-trial according to the equations of Gaesser and Brooks (1975):

GE = (Work accomplished/ Energy expended) x 100

During both the preliminary and experimental trials, heart rate was recorded at 5-s intervals using a Polar S810i heart rate monitor (Polar Electro OY, Kempele, Finland). The use of an electric fan produced an air speed of ~23 $km \cdot h^{-1}$ over the cyclist during all trials. Environmental conditions were maintained throughout each trial with mean temperature and relative humidity in the range 18-22°C and 45-55%, respectively.

Statistical analysis

Cycling performance times were converted to average time-trial speeds ($km \cdot h^{-1}$) (Nevill et al., 1992). Data derived from both respiratory gas analysis and the PowerTap powermeter device were recorded as a mean value for the duration of the time-trial. Using the SPSS statistical software package (SPSS for Windows, Rel. 15.0.1, 2006, Chicago: SPSS Inc.), a two-way ANOVA (crank system used during time-trial [CON_{TT}, ROT_{TT}] x crank system used during training [CON_{train}, ROT_{train}]) was performed to determine if there was a significant condition effect on the following variables: power output, cadence, speed, heart rate, VO_2, RER and gross efficiency. Statistical significance was set at $P \leq 0.05$ for all tests.

Table 2. Mean (±SD) performance and physiological variables during two time-trial conditions.

	CON	ROT
Time (min)	58.4 (5.2)	58.4 (5.0)
Speed ($km \cdot h^{-1}$)	41.7 (3.4)	41.6 (3.3)
Power output (W)	255 (44)	253 (40)
Cadence ($rev \cdot min^{-1}$)	87 (6)	86 (5)
Heart rate ($beats \cdot min^{-1}$)	162 (12)	160 (14)
VO_2 ($L \cdot min^{-1}$)	3.86 (.37)	3.83 (.43)
RER	.90 (.04)	.90 (.05)
TT gross efficiency (%)	19.2 (2.4)	19.3 (2.0)

CON = conventional crank TT, ROT = Rotor crank TT.

Results

There was no significant difference in gross efficiency measured prior to the commencement of each time-trial when using either the conventional or Rotor crank systems (CON_{TT} = 18.8% ±2.2 vs. ROT_{TT} = 19.4% ±2.0, $P > 0.05$). Data for each variable measured during the time-trials are presented in Table 2. (Note, although the mean RER during both time-trials was less than 1, TT gross efficiency is not an accurate measure of gross efficiency as the cyclists were not at steady state. These results are presented here for interest only.)

The two-way ANOVA did not identify a significant main effect of the time-trial condition (CON_{TT} vs. ROT_{TT}) on any of the measured variables ($P > 0.05$). Furthermore, the ANOVA identified no significant interaction effect between main effects (crank system used during time-trial [CON_{TT}, ROT_{TT}]*crank system used during training [CON_{train}, ROT_{train}], $P > 0.05$). Verbal feedback from participants suggested that the Rotor system "felt strange for the first few minutes", after which CON and ROT systems could not be differentiated.

Discussion

To the authors' knowledge, this is the first study to examine the effects of the Rotor system on a laboratory time-trial (i.e. endurance performance) rather than a constant load or incremental assessment (i.e. endurance capacity). The main finding was that the Rotor system had no measurable impact on the time taken to complete a 40.23-km laboratory time-trial. Furthermore, there were no statistical differences in any of the measured variables when using the Rotor system rather than conventional cranks.

The cam mechanism used in the Rotor system means that both cranks never reach the dead points (i.e. top and bottom dead centre) at the same time. Thus, by the time one crank has reached bottom dead centre, the other crank has been accelerated through top dead centre and has, therefore, entered the power stroke phase. Theoretically, this would enable the cyclist to stay closer to their maximum torque throughout the crank cycle, therefore increasing mean power output. Santalla et al. (2002) also suggested that the Rotor system might facilitate contralateral cooperation between the legs. When using the Rotor, the work of the leg carrying out the upstroke phase is assisted sooner by the other leg (than when using a conventional crank system) because the latter enters the power stroke phase sooner. Such contralateral cooperation would minimise the energy required to sustain a given power output; therefore, delaying fatigue (Lucia et al., 2004). However, the results of the current study suggest that the Rotor system does not affect time-trial cycling performance. This finding provides support for the work of Lucia et al. (2004) who found that the Rotor system had no beneficial impact on several predictors of cycling performance (VO_{2max}, W_{peak}, LT, OBLA, economy and gross and delta efficiency). Future studies should use electromyography to investigate whether or not the Rotor crank has any impact on normal muscular activity.

Lucia et al. (2004) suggested that experienced cyclists are able to 'slightly pull the pedal up' during the upstroke phase of the pedal duty cycle. Such an adaptation to training would mask the benefits of the contralateral cooperation provided by the Rotor system. This explanation is supported by the work of Santalla et al. (2002) who reported an improvement in delta efficiency in a group of non-cyclists when using the Rotor system. Not having developed the ability to pull the pedal up, these individuals would benefit from the contralateral cooperation provided by the Rotor. However, this explanation assumes that trained cyclists 'pull up' more than non-trained cyclists and, therefore, have a 'smoother' pedal action (Lucia et al., 2004). The work of Coyle et al. (1991) and, more recently, Edwards et al. (2009) actually suggests that more experienced cyclists have a less 'smooth' pedal action than less experienced cyclists.

The Rotor system may have no effect on time-trial performance because the enhancement of the torque profile provided by the Rotor is not of a sufficient magnitude to increase the submaximal power output generated during a 40.23-km time-trial. Unfortunately, the equipment used in the present study was unable to measure torque production at a high enough resolution to make comparisons between ROT and CON for individual pedal revolutions. Indeed, because the PowerTap device records torque at the rear hub, it is unlikely to be able to discern small torque differences at the crank.

Small torque increases at submaximal workloads may actually become significant at higher workloads. Thus, during events where power output is near maximal, the mechanical advantage provided by the Rotor system might provide significant performance benefits. This is supported by research that has shown that eccentric chainrings (that provide pedal duty cycle alterations similar to the Rotor) improve cycling performance during an all-out 1-km time-trial (Hue et al., 2001). Indeed, Rodriguez-Marroyo et al. (2009) have recently shown that use of the Rotor system leads to improved performance in maximal 30-s anaerobic sprints.

The Rotor system is designed to provide a mechanical advantage. However, it is possible that without sufficient habituation cyclists are unable to benefit from this as they are forced to carry out a movement pattern that would necessarily recruit the active musculature in an unfamiliar way. For this reason, half of the participants taking part in this study trained solely with ROT for a minimum of six weeks before completing the time-trial assessments. Whilst there was no statistically significant interaction effect between the pedalling system used during training and the pedalling system used during the time-trials, it was actually the CON_{train} group and not the ROT_{train} group that appeared to make a slight improvement (see Figure 1). The benefits of the Rotor system might therefore be gained by infrequent use (perhaps at key races). This might explain why, for non-habituated Rotor users, Santalla et al. (2002) reported an improvement in delta efficiency but, in a group that included habitual Rotor users, Lucia et al. (2004) did not.

It is possible that the non-ergogenic effect of the Rotor system was the result of the Rotor not being set in the optimal position for each rider (that is, where the neutral Rotor regulation point was adopted by all participants). However, recent findings suggest that this is unlikely to have had a major impact on the results of this investigation. Rodriguez-Marroyo et al. (2009) identified no significant differences in gross efficiency between ROT and CON systems even when the 'best' regulation point was used by each rider.

Conclusion

The results of this study support earlier findings that have suggested that use of the Rotor system does not affect the key predictors of cycling performance. The slight tendency towards improvement (~3% relative) in gross efficiency when using the Rotor system (similar to that seen in delta efficiency in the study of Lucia et al. [2004]), would not appear to be of a sufficient magnitude to affect time-trial cycling performance. However, future studies might consider the effects of adjusting the Rotor crank regulation point to accommodate the specific movement patterns of individual cyclists and ergometers.

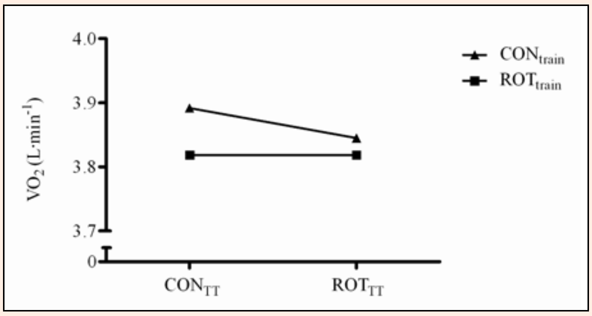

Figure 1. **Interaction between training pedal system (CON_{train} vs. ROT_{train}) and time-trial condition (CON_{TT} vs. ROT_{TT}) on mean VO_2.**

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References

Baguley, T. (2004) Understanding statistical power in the context of applied research. *Applied Ergonomics* **35**, 73-80.

Bertucci, W., Duc, S., Villerius, V., Pernin, J.N. and Grappe, F. (2005a) Validity and reliability of the PowerTap mobile cycling powermeter when compared with the SRM Device. *International Journal of Sports Medicine* **26**(10), 868-73.

Bertucci, W., Grappe, F., Girard, A., Betik, A. and Rouillon, J.D. (2005b) Effects on the crank torque profile when changing pedalling cadence in level ground and uphill road cycling. *Journal of Biomechanics* **38**, 1003-1010.

Coast, J., Cox, R. and Welch, H. (1986) Optimal pedalling rate in prolonged bouts of cycle ergometry. *Medicine and Science in Sports and Exercise* **18**, 225-230.

Cohen, J. (1988) *Statistical power analysis for behavioural sciences.* 2nd edition. Academic Press, New York.

Coyle, E.F. (1995) Integration of the physiological factors determining endurance performance ability. *Exercise and Sport Science Reviews* **23**, 25-64.

Coyle, E.F. (1999) Physiological determinants of endurance exercise performance. *Journal of Science and Medicine in Sport* **2**, 181-189.

Coyle, E.F., Feltner, M.E., Kautz, S.A., Hamilton, M.T., Montain, S.J., Baylor, A.M., Abraham, L.D. and Petrek, G.W. (1991) Physiological and biochemical factors associated with elite endurance cycling performance. *Medicine and Science in Sports and Exercise* **23**, 93-107.

Cullen, L.K., Andrew, K., Lair, K.R., Widger, M.J. and Timson, B.F. (1992) Efficiency of trained cyclists using circular and noncircular chainrings. *International Journal of Sports Medicine* **13**(3), 264-269.

Doherty, M., Nobbs, L. and Noakes, T.D. (2003) Low frequency of the "plateau phenomenon" during maximal exercise in elite British athletes. *European Journal of Applied Physiology* **89**(6), 619-623.

Edwards, L.M., Jobson, S.A., Day, S. and Nevill, A.M. (2009) Whole-body efficiency is negatively correlated with minimum torque per duty cycle in trained cyclists. *Journal of Sports Sciences* **27**(4), 319-325.

Erdfelder, E., Faul, F. and Buchner, A. (1996) GPower, a general power analysis programme. *Behavior Research Methods, Instruments & Computers* **28**: 1-11.

Faria, I.E. (1992) Energy expenditure, aerodynamics and medical problems in cycling. An update. *Sports Medicine* **14**, 43-63.

Gaesser, G.A. and Brooks, G.A. (1975) Muscular efficiency during steady-state exercise: effects of speed and work rate. *Journal of Applied Physiology* **38**, 1132-1139.

Gardner, A.S., Stephens, S., Martin, D.T., Lawton, E., Lee, H. and Jenkins, D. (2004) Accuracy of SRM and power tap power monitoring systems for bicycling. *Medicine and Science in Sports and Exercise* **36**(7), 1252-1258.

Hopkins, W.G. (2000) Measures of reliability in sports medicine and science. *Sports Medicine* **30**, 1-15.

Horowitz, J.F., Sidossis, L.S. and Coyle, E.F. (1994).High efficiency of type 1 muscle fibres improves performance. *International Journal of Sports Medicine* **15**, 152-157.

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

Hue, O., Racinais, S., Chamari, K., Damiani, M., Hertogh, C. and Blonc, S. (2008) Does an eccentric chainring improve conventional parameters of neuromuscular power? *Journal of Science and Medicine in Sport* **11**(3), 264-270.

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

Lucia, A., Balmer, J., Davison, R.C.R, Pérez, M., Santalla, A. and Smith, P.M. (2004) Effects of the rotor pedalling system on the performance of trained cyclists during incremental and constant-load cycle-ergometer tests. *International Journal of Sports Medicine* **25**(7), 479-485.

Moseley, L. and Jeukendrup, A. (2001) The reliability of cycling efficiency. *Medicine and Science in Sports and Exercise* **33**, 621-627.

Nevill, A.M., Jobson, S.A., Palmer, G.S. and Olds, T.S. (2005) Scaling maximal oxygen uptake to predict cycling time-trial performance in the field: a non-linear approach. *European Journal of Applied Physiology* **94**, 705-710.

Nevill, A.M., Ramsbottom, R. and Williams, C. (1992) Scaling physiological measurements for individuals of different body size. *European Journal of Applied Physiology* **65**, 110-117.

Norris, S.R. and Smith, D.J. (1999) Examination of the performance of three metabolic measurement systems. *Medicine and Science in Sports and Exercise* **31**(5 Suppl.), S302.

Olds, T., Norton, K., Craig, N., Olive, S. and Lowe, E. (1995) The limits of the possible: Models of power supply and the demands in cycling. *Australian Journal of Science and Medicine in Sport* **27**, 29-33.

Paton, C.D. and Hopkins, W.G. (2006) Ergometer error and biological variation in power output in a performance test with three cycle ergometers. *International Journal of Sports Medicine* **27**(6), 444-447.

Petersen C.J., Wilson, B.D. and Hopkins W.G. (2004) Effects of modified-implement training on fast bowling in cricket. *Journal of Sports Sciences* **22**, 1035-1039.

Ratel, S., Duché, P., Hautier, C.A., Williams, C.A. and Bedu, M. (2004) Physiological responses during cycling with noncircular "Harmonic" and circular chainrings. *European Journal of Applied Physiology* **91**(1), 100-104.

Rodríguez-Marroyo, J.A., García-López, J., Chamari, K., Córdova, A., Hue, O. and Villa, J.G. (2009) The rotor pedaling system improves anaerobic but not aerobic cycling performance in professional cyclists. *European Journal of Applied Physiology* **106**(1), 87-94.

Santalla, A., Manzano, J.M., Pérez, M. and Lucía, A. (2002) A new pedaling design: the Rotor--effects on cycling performance. *Medicine and Science in Sports and Exercise* **34**(11), 1854-1858.

Wasserman, K.W., Hansen, J.E., Sue, D.Y., Stinger, W.W. and Whipp, B.J. (2005). *Principles of Exercise Testing and Interpretation*. Lippincott, Williams and Wilkins, Philadelphia.

Key points

- The Rotor crank system does not improve gross efficiency in well-trained cyclists.
- The Rotor crank system has no measurable impact on laboratory 40.23-km time-trial performance.
- A 6-week period of familiarisation does not increase the effectiveness of the Rotor crank system.

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