Does a Non-Circular Chainring Improve Performance in the Bicycle Motocross Cycling Start Sprint?

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Abstract

Maximising power output during the initial acceleration phase of a bicycle motocross (BMX) race increases the chance to lead the group for the rest of the race. The purpose of this study was to investigate the effect of non-circular chainrings (Q-ring) on performance during the initial acceleration phase of a BMX race. Sixteen male cyclists (Spanish National BMX team) performed two counterbalanced and randomized initial sprints (3.95s), using Q-ring vs. circular chainring, on a BMX track. The sample was divided into two different groups according to their performance (Elite; n = 8 vs. Cadet; n = 8). Elite group covered a greater distance using Q-ring (+0.26 m, p = 0.02; D = 0.23), whilst the improvement for the Cadet (+0.04 m) was not significant (p = 0.87; D = -0.02). Also, there was no significant difference in power output for the Elite group, while the Cadet group revealed larger peak power with the circular chainring. Neither lactate level, nor heart rate showed significant differences due to the different chainring used. The non-circular chainring improved the initial acceleration capacity only in the Elite riders.

Key words: Power, efficiency, pedalling, biomechanics, lactate.

Introduction

Bicycle Motocross (BMX) is a new Olympic sport that involves covering a specific course as fast as possible in order to achieve the best final position. Taking a good position at the front of the group at the beginning of the race is crucial, since positions hardly change during the race. This is because races are conducted in mass start rounds of eight riders and riders must accelerate and take the best possible position during the first meters in the descending lane after the start, specifically until the first obstacle. Past the descending lane, front riders strategically occupy the best places to achieve maximum performance (Mateo-March et al., 2012a). Therefore, sprinting ability is one of the key skills during the initial acceleration phase after the start (Debraux and Bertucci, 2011; Mateo et al., 2011; Bertucci and Hourde, 2011). As a result, scientific literature examining BMX cycling has mainly focused on the initial acceleration phase (Bertucci et al., 2007; Debraux and Bertucci, 2011; Mateo et al., 2011; Zabala et al., 2009; Debraux et al., 2013).

In order to enhance power output and improve the pedalling mechanics in cycling, non-circular pedalling

systems were first developed in 1977 (Henderson et al., 1977). They aimed to compensate for the changes and losses of force application throughout the pedal stroke on the basis that when the cranks are at either top or bottom dead centre, propulsive forces tend to be minimal (Ericson and Nisell, 1988). Briefly, non-circular pedalling systems can be divided into 1) non-circular chainrings with the major axis parallel to the cranks in order to help overcoming both dead centres (e.g. "Biopace" system; (Hull et al., 1992) and 2) non-circular chainrings with the major axis perpendicular to the cranks in order to increase the gear ratio during the downstroke e.g. "Harmonic Chainring"; (Ratel et al., 2004). Despite the large theoretical basis behind eccentric chainrings, however, their potential benefits are unclear. An early study found that the metabolic demand during an incremental test to exhaustion was unchanged with elliptical chainrings (Henderson et al., 1977). Other studies showed short-term power output improvements (Hue et al., 2001), or kinematic improvements, reduced angular decelerations in the knee joint and reduced range of movement in the ankle joint (Carpes et al., 2009). Thus, it appears that non-circular chainrings might enhance short duration and high power demand disciplines, like BMX and most track modalities (Mateo et al., 2010; Hue et al., 2007; 2008).

Recently, a new chainring called the "Q-ring" has been developed (Rotor Bike Components, Madrid, Spain). As with other elliptical chainrings, the Q-ring progressively increases the chainring diameter and gear ratio during the downstroke, aspect that leads to the theoretical assumption of increasing the time for force production at the downstroke phase, improving the torque production ability. In addition, the orientation of the major axis can be adjusted against the crank to match the individual technical characteristics of the cyclist. This option is called the optimum chainring position, which theoretically allows the cyclist to apply maximal force at an optimal point of the downstroke. This then adapts the applied torque to the requirements of the road (climbing or in flat terrain, etc.), or to the rider's biomechanical characteristics (Córdova et al., 2009). Important aspect because, as shown by Neptune and Herzog (2000), perpendicular orientation of an elliptical chainring produces slightly higher crank torque patterns during the downstroke when compared to a parallel orientation. This would then allow cyclists who are able to produce higher

Table 1. **Descriptives of anthropometric characteristics and training background. Data are means (±SEM).**

	Elite group, (n = 8)	Cadet group, (n = 8)	Cohen's d	effect size r
Age (years)	23.3 (.9)	15.8 (.2) *	2.318	.757
Mass (kg)	77.7 (.6)	56.4 (.5) *	2.007	.708
Stature (m)	1.76 (.04)	1.66 (.03) *	1.286	.54
Fat-free mass (Martin[#]) (kg)	48.2 (.1)	44.8 (.2)	1.394	.571
Fat mass (Faulkner[#]) (%)	11.3 (.1)	14.1 (.2)	-.98	-.452
Experience (years)	7.0 (1.6)	5.0 (1.1) *	1.45	0.58
Training (h/day)	3.2 (.2)	2.7 (.3)	0.665	0.315
Training (Sessions/week)	11.2 (1.2)	9.0 (.8)	0.626	0.298

[#] (Martin & Drinkwater, 1991; Faulkner, 1968). * $p < 0.05$.

torque in the downstroke (i.e. better or stronger riders) to be advantaged when compared to weaker cyclists with this kind of non-circular chainring. This may also be the case in BMX disciplines.

On the other hand, it is well known that the weaker riders choose smaller gear ratios to improve their performance in cycling road modalities. Even more, due to the lack of strength, the rules limit these gear ratios through the young categories (i.e. for juniors, men and women), the maximum gear ratio authorized is that which gives a distance covered per pedal revolution of 7.93 m; (UCI, 2013). However, there is no gear ratio limitation in the BMX discipline.

We hypothesized that the non-circular chainring (Q-ring) could improve performance and maximal power output during the initial acceleration phase (3.95s) of a BMX race, but this improvement would be greater in the Elite riders compared to the Cadet riders. Therefore, the aim of the present study was to determine whether differences in performance, power and metabolic variables existed when using a non-circular chainring in comparison with a standard circular chainring.

Methods

Participants

Sixteen male BMX riders from the Spanish national team, aged 15-24 years, volunteered to participate in the study. None of these participants had any previous experience in riding with non-circular chainring systems however; they were familiar with all other testing procedures because they were based on habitual training and competition tasks. In order to analyse performance differences, cyclists were classified into two groups using a median split technique according to the overall average performance (total distance) obtained with both chainrings (non-circular and circular) during the two days of testing. These two samples separated by performance coincided with the different competing categories of age (Cadet vs. Elite, and would be named as Cadet the first two, and Elite the latest -15.8 vs. 23.3 years, respectively-). The best eight cyclists were included in the Elite group, while the worst eight cyclists were included in the Cadet group (Table 1). The study, approved by the Ethics Committee of the University of Granada (Spain), was conducted according to the principles of the Declaration of Helsinki and the cyclists gave written informed consent for participation. As the athletes were at a training camp for monitoring and assessing the national team during the experi-

mental procedures, their food intake, hydration, legal drug use, physical activity patterns, recovery times and sleep times were accurately controlled. (Faulkner, 1968; Martin and Drinkwater, 1991)
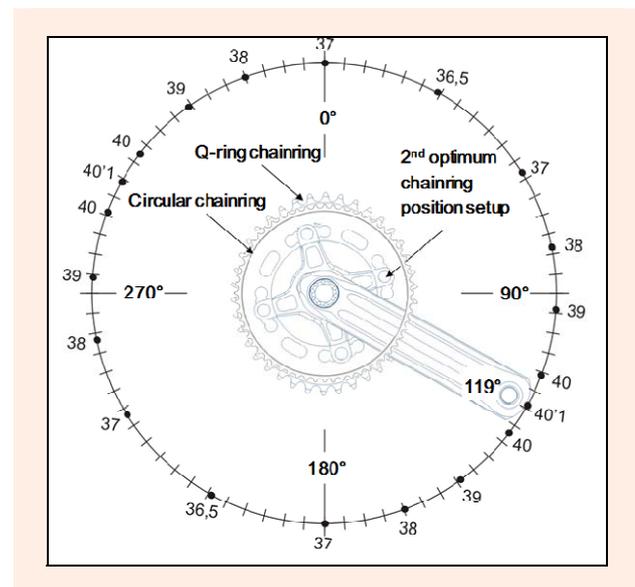

Figure 1. Variable gearing elicited by the non-circular chainring during the pedal stroke at optimum chainring position of 119º.

The non-circular chainring (Q-ring)

The Q-ring is a non-circular chainring approved by the UCI that aims to optimise pedalling mechanics without increasing the mass of the bicycle. For this study, we used a 38-tooth chainring, which was especially designed to be used in single sprocket bikes like track and BMX bicycles. Due to the eccentricity of the Q-ring, the equivalent gear ratio varied from 36 teeth along the major axis (and thus when the cranks are near top and bottom dead centres) to 40 teeth along the minor axis (when the cranks are near horizontal). This is in contrast to circular chainrings that provide a constant gear ratio throughout the whole pedal stroke. The above mentioned optimum chainring position system allows the rider to fix the minor axis of the Q-ring in the optimum individual position with respect to the cranks, i.e. the point at which the cyclist generates the largest torque during the downstroke. The five optimum chainring positions of the Q-ring were separated by 8º (0 = 103º, 1 = 111º, 2 = 119º, 3 = 127º and 4 = 135º). In this study we used position 2 (119º) setup as recommended by the manufacturer for non-accustomed

cyclists such as our subjects (Figure 1). This chainring setup has been used in previous research (Rodríguez-Marroyo et al. 2009), and other studies that have compared different Force-velocity relationship of each functional sector (i.e., extension, flexion, and transitions sectors) on the total force produced over a complete pedalling cycle, finding that around this crank angle shows the best values of Force-velocity production (Dorel et al., 2010).
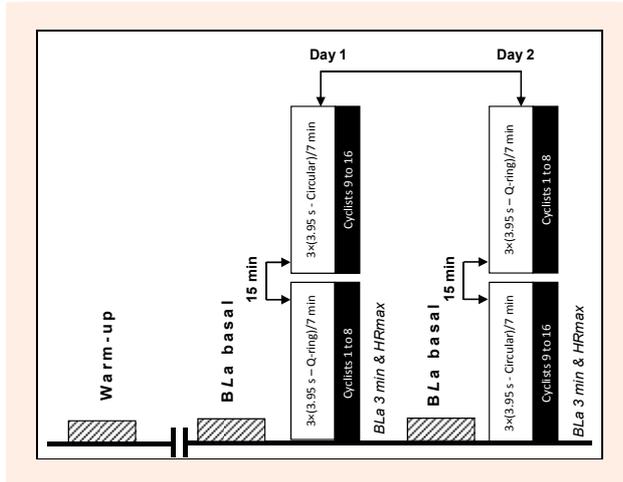

Figure 2. Experimental protocol showing randomized and counterbalanced trials with Circular and non-circular (Q-rings) chainrings. Note that the cyclist's numbers (1 to 16) were randomly assigned and that Elite and Cadet group differentiation was made *a posteriori*.

Procedures
Cyclists were tested during two consecutive days on a standard BMX track and a standard BMX bicycle. The track was accredited to hold important events such as European championships and Spanish national championships. All subjects used the same conventional BMX bicycle (Redline Proline, Redline, Seattle, USA), individually adapted to match each rider's individual set up measurements (handlebar alignment relative to the vertical and the saddle height). Settings were adjusted by each rider according to their preferences. Before the first testing day, subjects refrained from exhaustive exercise for at least 48 hours, and other possible influencing variables were controlled (i.e., caffeine ingestion was not allowed).

Each testing session started with a standardised warm-up lasting 35 minutes. During the first 20 minutes, the subjects rode the bicycle at an increasing pace that elicited a heart rate of approximately 100 to 155 beats·min^{-1} (Polar RS800 HR monitor and an electrode transmitter belt T61) with the non-circular chainring. Then, they performed two sprints with each type of chainring. This warm-up also served as a familiarisation period with both chainrings (although participants reported feeling no difference between them).

After warming up, cyclists performed two sprint bouts, each one consisting of three maximal acceleration sprints from the gate-start platform. On day one, the first two sprint bouts were performed, in random order, with either the Q-ring or the circular chainring. On day two the order was swapped, thus avoiding any possible ordering effect. Additionally, on day two each subject was tested at the same time (between 9:00 am and 2:00 pm) and under the same atmospheric conditions (15-19° C and 80% relative humidity) as in day one. Recovery periods were set at 7 minutes between sprints and 15 minutes between sprint bouts, and riders were permitted to drink water in the meantime *ad libitum*. This protocol was devised to prevent the onset of fatigue (Figure 2).

Measurements
The rear wheel was equipped with a G-Cog powermeter (Rennen Design Group, Middleboro, Massachusetts, USA) (Figure 3). This powermeter, which has shown to be valid and reliable (Bertucci et al., 2013; Chiementin et al., 2013; Mateo et al., 2010) incorporated two angular accelerometers, two centripetal accelerometers and two lateral accelerometers so that distance, angular and linear velocity and first movement of the bike could be calculated. The force applied to the sprocket was measured by two piezoelectric sensors, from which power was calculated. All data was collected at 250 Hz for further analysis.
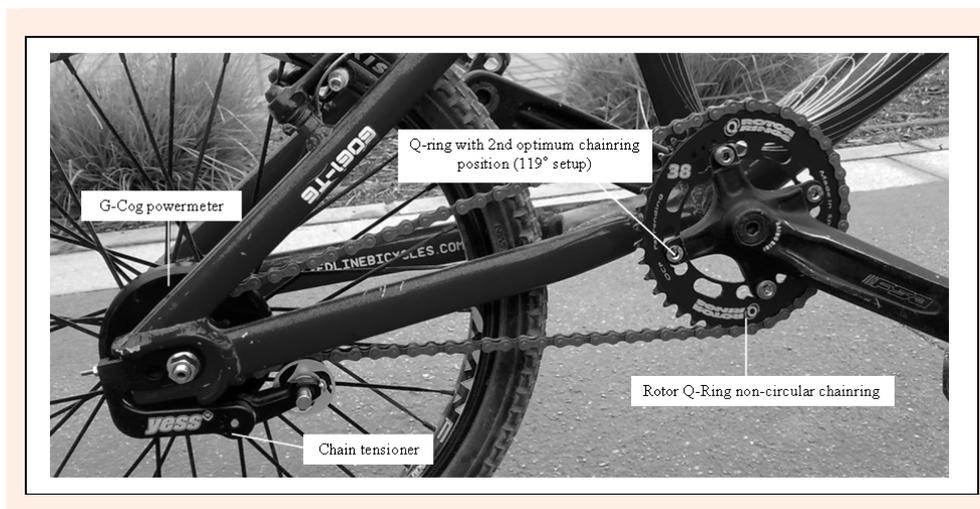
Figure 3. The customized BMX bicycle showing the non-circular chainring in 2nd optimum chainring position or 119º, Yesspro chain tensioner and G-Cog electronic measuring device.
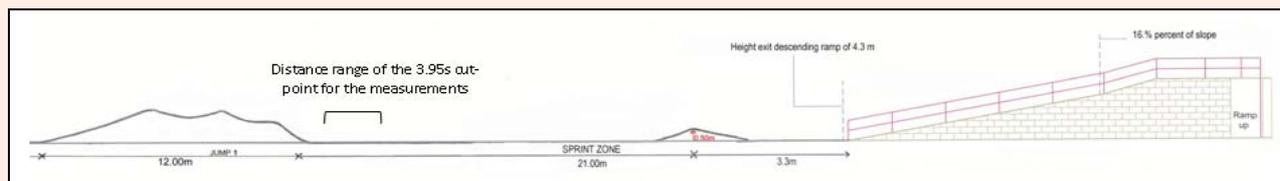
Figure 4. Scale illustration of the BMX track.

The sprints started from an official BMX starting ramp and start gate that was triggered by an official acoustic signal (Bensink BMX gates, Voorst, Nederland) Thus, we replicated the actual BMX starting conditions, with the exception that cyclists were tested on their own and not in a mass start. After the starting signal the rider accelerated as powerfully as he could. The track layout consisted of an exit descending ramp of 4.3 m and a 16% slope, then a flat distance of 3.3 m to the first obstacle (small speed jump, with no technical difficulty), and then another flat and straight line of 23.3 m (Figure 4).

All subjects used the same crank length (175 mm), the same gear ratio (38 x 14), the same clipless pedals (Shimano SPD DX, Shimano Corp., Japan), and the same tyre pressure (50 psi). This was the standard equipment typically used in competition by our cyclists. Both non-circular and circular chainrings were produced by the same manufacturer and were equivalent in weight, teeth number, etc., so that all characteristics remained constant except for the shape. The 15-minute recovery periods between sprint bouts were used to change the selected chainring (non-circular or circular chainring), always by the same researcher. The non-circular chainring produces a vertical oscillation in chain tension due to intra pedal-stroke gear ratio variations, which might cause transmission malfunction in single-speed bicycles. This problem was avoided by using a Yess ETR/H chain tensioner (Yesspro, British Columbia, Canada) (Figure 3), which was also used in the circular chainring condition to avoid any kind of difference.
Heart rate data was continuously registered by means of a Polar RS800 HR monitor (Polar Electro, Kempele, Finland) and an electrode transmitter belt (T61), after application of conductive gel as recommended by the manufacturer. Prior to testing and three minutes after completion of the last sprint, a small sample of blood was taken from the ear lobe and blood lactate was analysed with a Lactate Pro™ portable lactate analyser (Arkray, KDK Corporation, Minami-Ku, Kyoto, Japan).

Variables
With the aim of comparing performance between non-circular and circular chainrings, different variables were measured and calculated. Even though the cyclists were asked to sprint for about 7 s, only the first 3.95 s from the bike's first movement were analysed. This duration was chosen because it was the time that it took the best riders to arrive at the beginning of the second obstacle of the track (medium double). Therefore, the start sprinting ability was assessed by minimising the influence of individual technical skills and reaction times on performance variables. The measured variables included the distance

covered in those first 3.95 s (total distance), and the maximum heart rate during the sprint. Calculated variables included the absolute maximal and mean power output, the time to achieve the peak power output, the power index and the efficiency index (Chiementin et al., 2012a; 2012b). The power index, defined as the ratio between the peak power and the time to achieve this peak power, provides information about the rate of power development. The efficiency index, calculated to assess the efficiency developed with the two chainrings, is defined as the ratio between the mean power and the total distance covered in the 3.95 s period. Finally, the baseline blood lactate concentration was measured prior to warm-up and 3 minutes after the last sprint of each bout so that the percentage of increase respect to baseline was calculated.

Statistical analysis
Statistical analysis was carried out using SPSS software version 15.0 (Chicago, IL, USA). The Shapiro-Wilk Test was applied to determine whether there was a Gaussian distribution of the results, followed by Levene's test to verify the homogeneity of variance. The main characteristics of the two groups (Elite and Cadet levels) were compared using student's paired t-test and Cohen's effect sizes (r) were computed for the analysis of magnitude of the differences, and rated as trivial (<0.25), small (0.25-0.49), moderate (0.5-1.0), and large (>1.0) (Cohen 1988), while the non-parametric Wilcoxon matched pairs-signed rank test was used to compare circular vs. non-circular chainring data, since this set of data did not exhibit normal distribution, and therefore, Cliff's Delta statistic was calculated by to quantify the magnitude of the difference between the two groups of observations (Macbeth et al. 2010). The coefficient of variation (% CV) for each device, and the percentage difference of the average values between Q-ring and Circular data (% Dif), was obtained in order to compare the variability in both data sets. Results were expressed as mean and standard error of the mean (SEM). The level of significance was set $p < 0.05$ for all tests.

Results

Elite group (n = 8)
The Elite group improved significantly the distance covered with the Q-ring chainring system (p = 0.02; D = 0.23), which meant an average improvement of 0.26 m. Mean efficiency index was also better with the Q-ring (Table 2), although there were no significant differences (p = 0.73; D = -0.13). 3.95s was time enough to increase lactate levels to over 40% from baseline conditions, with larger but no significantly different (p = 0.81; D = -0.15),

Table 2. Power, performance and metabolic variables (mean ± SEM) for the Cadet group and the Elite group during the initial acceleration phase using the non-circular (Q-ring) and circular chainrings.

| | Elite group, n = 8 | | | | | | Cadet group, n = 8 | | | | | |
| | Q-ring | | Circular | | Q vs Circular | | Q-ring | | Circular | | Q vs Circular | |
	M (SEM)	%CV	M (SEM)	%CV	%Dif	D	M (SEM)	%CV	M (SEM)	%CV	%Dif	D
Power Variables												
PP (W)	1706 (54)	3.00	1757 (77)	3.00	-2.90	.06	1272 (65)	5.00	1408 (53) #	4.00	-9.66	-.25
MP (W)	455 (29)	6.00	524 (40)	6.00	-13.17	-.10	295 (28)	9.00	347 (25)	7.00	-14.99	-.04
TPP (s)	1.53 (.04)	2.00	1.49 (.06)	2.00	2.68	.07	1.50 (.05)	3.00	1.48 (.05)	3.00	1.35	-.06
PP / TPP (W s^{-1})	1157 (54)	5.00	1294 (86)	5.00	-10.58	-.06	854 (58)	7.00	954 (68)	7.00	-10.52	-.12
Performance Variables												
TD (m)	23.42 (.07) *	.20	23.16 (.09)	.40	1.12	.23	21.61 (.27)	1.00	21.57 (.24)	1.00	.19	-.02
‡ MP / TD (W m^{-1})	19.36 (1.23)	6.00	22.63 (1.73)	8.00	-14.45	-.13	13.44 (1.20)	9.00	16.1 (1.15)	7.00	-16.52	-.22
Metabolic Variables												
BLa (mMol)	3.79 (.24)	6.00	4.22 (.32)	8.00	-10.19	-.14	3.68 (.31)	8.00	3.51 (.36)	10.00	4.84	.11
Lactate increase (%)	40.5 (10.6)	26.00	44.6 (9.2)	20.00	-9.36	-.15	46.8 (7.4)	16.00	40.8 (7.5)	18.00	14.87	.15
Max HR (beats·min^{-1})	157 (1)	1.00	158 (1)	1.00	-.63	-.10	160 (2)	1.00	158 (2)	1.00	1.27	-.04

PP: Peak power. MP: Mean power. TPP: Time to peak power. TD: Total distance. Max HR: Maximum heart rate. M (SEM): Mean (±Standard Error Mean). (D) Cliff's Delta effect size; low (.20), moderate (.30) and large (.50). % Dif Percentage difference of the average value between Q-ring and Circular respect to Circular chainring. % CV Coefficient of variation. ‡ Efficiency index
* Significant difference between Q-ring and Circular chainrings for Q-ring (p < 0.05)
# Significant difference between Q-ring and Circular chainrings for Circular (p < 0.05)

values for the circular chainring condition in this group (Table 2).

Cadet group (n = 8)

In contrast with the Elite group, there were no significant differences regarding performance (total distance in 3.95 s) (p = 0.87; D = -0.02). Moreover, the Cadet group showed better peak power outputs (p = 0.01; D = -0.25) with the circular chainring. On the other hand, the mean efficiency index remained higher for the non-circular chainring condition, whilst the percentage of lactate increase was larger for the Q-ring (Table 2). Neither of these two differences (efficiency index and % lactate) was significantly different (p = 0.09; D = -0.22 and p = 0.63; D = 0.15, respectively).

Discussion

Based on previous research (Córdova et al., 2009), we hypothesised that the non-circular chainring would improve performance in BMX cycling by increasing the power outputs, the effectiveness of the applied force, or both, due to a probable more advantageous mechanical situation during the downstroke. The doubt was whether this advantage was related to the cyclist level. The main finding of the study was that the non-circular chainring actually improved performance during the starting sprint in the BMX cycling discipline, which supports our initial hypothesis; but this performance improvement was not related to better power outputs, and it was somewhat limited to the level of the riders (Elite group in our study). Indeed, the lower level cyclists developed significantly larger peak power outputs with the traditional circular chainring, and even when they exhibited better efficiency indices with the Q-ring, it was no enough to cover a larger distance.

The non-circular chainring system appears to be able to alter power generation so that drive to the rear wheel can be improved despite lower average power output. This may allow a decreased time between the dead centres during the pedalling cycle. This can improve pedalling technique to a smoother cycling action that generates power more progressively.

On one hand, this difference in the Cadet group could be mainly attributed to their lower ability to develop a high amount of propulsive torque during the downstroke with both chainrings (Table 2), which in turn causes the resultant instantaneous gearing to be too large for them, and further studies will be necessary to conclude that the OPC-38 suggested by the manufacturer is a too big gear ratio for the less skill BMX riders. This can be explained by the lower age (mean age = 15.6 years for the Cadet group vs. 23.2 years for the Elite group), and, more importantly, by the lower body mass of the Cadet group (mean body weight = 56.4 kg for the Cadet group vs. 77.8 kg for the Elite group), both significantly different, as shown in Table 1. When considering the non-circular chainring condition as an example, this showed a mean power/body mass ratio of 5.2 W·kg^{-1} for the Cadet group and 5.9 W·kg^{-1} for the Elite group, which undoubtedly diminishes the ability of the Cadet group to achieve a large propulsive torque during the downstroke. Our performance results (total distance and efficiency index) suggest that most powerful cyclists have been able to manage the increased load requirements produced by the non-circular chainring during the downstroke, while less powerful cyclists had more difficulties even though they have been able to move the circular chainring with the same number of teeth.

As expected for a so brief period of time, nor lactate or heart rate showed any significant difference. The elite group performed higher lactates with the circular chainring, whilst the Cadet group performed higher lactate increases when using the Q-ring device, but it was no significant. Further studies should analyse the lactate production in longer distances, since lactate is related to strength and muscle mass. Based on these results, it appears that special attention needs to be paid when selecting the chainring or the optimum chainring position that will be used in competition. In agreement with other re-

search we used position number two as a standard position to identify the optimum chainring (Rodríguez-Marroyo et al., 2009), although this might not be the best set up for each rider, as new studies have shown, being the OCP point 3 and 4, those who have obtained better results (Mateo-March et al., 2012b). Therefore, this aspect plays into the results of this study as making a better adjustment of the torque delivery point, possibly the performance gains are greater.

On the other hand, another important issue when considering BMX races is that the small improvement in performance with the non-circular chainring in the Elite group (0.26 m with non-circular chainring) is relevant in these competitions because riders have to fight for the best position in front of the bunch during the first 20 m of the race. Increasing the total distance covered in the first 3.95 s by 0.26 m means a 1.12% improvement that might allow a rider to overtake the surrounding opponents at the first turn, lead the group without standing in the way, and be able to develop all the pedalling ability during the rest of the race. Therefore, those 0.26 m can become several metres at the finish line, which implies that this small numerical difference has a big practical significance (Atkinson, 2003). This is particularly relevant when the technical standard of the riders is higher because technical mistakes rarely occur. Thus, improving performance by using a different type of chainring has a very interesting cost-benefit ratio. The results show that the non-circular chainring system is able to improve performance, and this improvement could be attributed to the improvement of the pedalling technique when passing through the top and bottom dead centre points during the pedalling cycle, presumably stating that increased force production at the larger radius of the chainring could be the expected improvement in technique. This was reflected by the lower efficiency index values for the non-circular chainring compared to the circular chainring, both for Elite and Cadet groups, which in turn implies a better mechanical distribution of forces in the pedalling action. Accordingly, future research should analyse whether this practical improvement in sprinting performance is brought about by (1) a mechanical improvement in force application, (2) a difference in the muscle activity pattern required in the implied kinetic chains, (3) an improved muscular coordination during the pedalling cycle, or (4) a combination of some of them.

A strong point of this study is that the sprint variables were assessed in a real setting, i.e. in an actual BMX racing track, thus accounting for features that cannot be reproduced in laboratory conditions, such as lateral oscillations of the bike (Bertucci et al., 2005) and aerodynamic resistance (Martin et al., 2007). Although some authors have not found differences between field and laboratory testing for maximum power and pedalling rate (Gardner et al., 2007), others found significant differences in the torque profile between road and laboratory pedalling conditions (Bertucci et al., 2007). Bearing in mind that force in BMX bicycles is applied in a very particular pattern due to a descending start and varied obstacles along the track, we believe that this issue deserves special consideration when testing BMX riders.

One potential limitation of this study is that the cyclists involved in our study had no previous experience in pedalling with any kind of eccentric chainring, and therefore it could be argued that this may have somehow affected the results. However, previous studies found that the participants can become accustomed to pedalling with elliptic chainrings after 20 minutes (Hull et al., 1992) and that muscular coordination adaptation to different chainrings may occur during the first 10-20 pedal strokes (Neptune and Herzog 2000). Another limitation of this investigation is that only the initial acceleration phase, from the starting line to the start of the second obstacle, was measured, as this is of paramount importance in BMX final performance. Even though there was an improvement of 0.26 m in the first 23 m of the track, it has to be determined whether the cyclists would be able to maintain that speed for the rest of the race. Indeed a hypothetical loss in power output during the second part of the race due to the non-circular chainring might occur, although previous research showed no differences in a Wingate test of similar duration between non-circular and circular chainrings (Córdova et al., 2009). Even if a reduction in power output occurred, the faster start (and therefore the better position in the bunch) would most likely compensate for it.

Conclusion

Counterbalanced trials in our study showed that the best BMX riders were able to improve significantly the performance (total distance) in the initial sprint with the Q-ring system, despite the absence of significant differences in power outputs. Increasing the total distance covered in the first 3.95 s by 0.26 m means a 1.12% improvement and points to be a sufficient reason to favour the Q-ring chainring, since it could be translated to several metres at the finish line.

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Key points

- This work provides novel results demonstrating very significant improvements in the sprint performance of BMX cycling discipline using a non-circular chainring system.
- This study seeks a practical application from scientific analysis.
- All data are obtained in a real context of high competition using a sample comprised by the National Spanish Team.
- Some variables influencing performance as subjects' physical fitness are discussed.
- Technical equipment approved by International Cycling Union is studied to check its potentially beneficial influence on performance.

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